

INDIUM TIN OXIDE-BASED Q-SWITCHED FIBER LASER GENERATION
AND SENSING APPLICATION

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DEDICATION

*Every challenging work needs self-effort as well as support,
especially to my lovely person.*

*I dedicate my humble effort to my loving parents,
Zalkepali @ Zulkefli Bin Ahmad;
Hayati Binti Banon;*

*my dearest siblings,
Muhammad Dhiyauddin Hakimi;
Noor Nazura Husna;*

*last but not least to
Muhammad Nazeem Bin Abd Rahim.*

May Allah bless all of you and shower your life with happiness.



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ABSTRACT

A pulsed fiber laser has gained significant attention due to widespread and useful photonics applications in the fields of high-speed communications, optical imaging, and material processing. Q-switching and mode-locking are two possible pulse fiber lasers that can be generated using active and passive techniques. The active technique requires a bulky and complex modulator, but the passive technique uses only a piece of a nanomaterial as a saturable absorber (SA) to induce loss modulation in laser configurations. In this regard, the active material of indium tin oxide (ITO) was used to build a SA device through DC magnetron sputtering in generation Q-switched pulse erbium-doped fiber laser (EDFL). ITO was never used for tuning wavelength with an intra-cavity filter and the application of pulse fiber laser such as a sensor. Two different implementation methods of ITO were successfully fabricated and characterized for Q-switching. The first ITO was deposited onto fiber ferrules to observe the performances of Q-switched pulse EDFL using various configurations such as linear, single ring, and Figure-8 cavities that have the repetition rate of 18.20 kHz, 38.03 kHz, and 24.19 kHz, respectively. Thus, the single ring configuration was selected and improved to enable Q-switched wavelength tunability by employing a tunable bandpass filter (TBF). The tunable Q-switched pulse EDFL wavelength was operated from 1540.0 nm to 1570.0 nm. The generated output pulses displayed a repetition rate of 94.34 kHz and the shortest pulse width of 3.22 μ s at the maximum pump power of 378.6 mW. Next, the stable switchable dual wavelength was generated by the aid of two selected fiber Bragg gratings in the single ring cavity. To achieve a flexible switched in individual wavelength of 1532 or 1533 nm and a simultaneous dual-wavelength fiber laser, the in-line polarization controller had to be adjusted. The second device implemented onto the side-polished fiber, coated with ITO (SPF-ITO), had generated as a novel method for Q-switching and ammonia sensor. The SPF-ITO was successfully utilized as the SA as well as a sensor for monitoring different concentrations of the ammonia solution. The pulsed fiber laser ammonia sensor can be observed through the shifts in wavelength and frequency domain due to the interactions between the ammonia

molecules and ITO thin film where the SPF-ITO was immersed in the ammonia solution. The shifts of wavelength from 1558.45 nm to 1554.25 nm resulted from the increase in ammonia concentrations from 0.5×10^5 to 3.0×10^5 ppm. The wavelength shifted from 1561.30 nm to 1559.35 nm using an increased concentration of ammonia from 1 to 10 ppm. Meanwhile, the shifts of RF signal from 35.50 kHz to 43.50 kHz were the result of the change in ammonia concentrations from 0.5×10^5 to 3.0×10^5 ppm. The RF signal shifted from 30.10 kHz to 33.70 kHz in tandem with the increase of ammonia concentrations from 1 to 10 ppm. In brief, the SPF-ITO was successfully fabricated for the Q-switcher as well as the sensor.



ABSTRAK

Laser gentian denyutan ini mendapat perhatian yang ketara kerana aplikasi fotonik yang meluas dan berguna dalam bidang komunikasi berkelajuan tinggi, pengimejan optik dan pemprosesan bahan. Pensuisan-Q dan mod-kunci adalah dua kemungkinan laser gentian denyutan yang boleh dihasilkan menggunakan teknik aktif dan pasif. Teknif aktif memerlukan modulator yang besar dan kompleks tetapi teknik pasif hanya menggunakan secebis bahan nano sebagai penyerap tenua (SA) untuk mendorong kehilangan modulasi dalam konfigurasi laser. Dalam hal ini, bahan aktif indium timah oksida (ITO) digunakan untuk membina peranti SA melalui *DC magnetron sputtering* untuk menghasilkan pensuisan-Q laser gentian terdop-erbium (EDFL). ITO tidak pernah digunakan untuk menala panjang gelombang dengan intra-rongga penapis dan aplikasi laser gentian denyutan seperti sensor. Dua kaedah pelaksanaan ITO yang berbeza berjaya difabrikasikan dan dicirikan untuk pensuisan-Q. ITO pertama didepositkan ke atas hujung gentian optik untuk memerhati prestasi pensuisan-Q denyutan EDFL menggunakan pelbagai konfigurasi seperti linear, cincin tunggal dan Rajah-8 yang mempunyai kadar pengulangan linear, cincin tunggal dan Rajah-8 masing-masing adalah 18.20 kHz, 38.03 kHz dan 24.19 kHz. Oleh itu, konfigurasi cincin tunggal dipilih dan ditambah baik untuk membolehkan pensuisan-Q penalaan panjang gelombang menggunakan penapis boleh laras (TBF). Panjang gelombang laser gentian pensuisan-Q yang boleh ditala beroperasi dari 1540.0 nm hingga 1570.0 nm. Pengeluaran denyut yang dihasilkan memaparkan kadar pengulangan 94.34 kHz dan lebar nadi terpendek 3.22 μ s pada daya pam maksimum 378.60 mW. Kemudian, dwi-panjang gelombang yang stabil boleh ditukar dengan bantuan dua gentian optik berparut Bragg (FBGs) di rongga cincin tunggal. Untuk mencapai fleksibel panjang gelombang individu yang berubah-ubah pada 1532 atau 1533 nm dan laser serat dwi-panjang gelombang ganda serentak, pengawal polarisasi selaras disesuaikan. Peranti kedua yang diimplementasikan pada gentian penggilap sisi, dilapisi dengan ITO (SPF-ITO), telah dihasilkan sebagai kaedah baru untuk pensuisan-Q dan sensor amonia. SPF-ITO berjaya digunakan sebagai SA dan juga penderiaan untuk memantau

kepekatan larutan amonia yang berlainan. Penderiaan amonia laser serat nadi dapat diperhatikan melalui perubahan panjang gelombang dan domain frekuensi kerana interaksi antara molekul amonia dan filem nipis ITO di mana SPF-ITO direndam dalam larutan amonia. Perubahan panjang gelombang dari 1558.45 nm hingga 1554.25 nm disebabkan oleh peningkatan kepekatan amonia dari 0.5×10^5 hingga 3.0×10^5 ppm. Panjang gelombang beralih dari 1561.30 nm ke 1559.35 nm kerana menggunakan kepekatan amonia yang meningkat dari 1 hingga 10 ppm. Sementara itu, perubahan isyarat RF dari 35.50 kHz hingga 43.50 kHz adalah hasil perubahan kepekatan amonia dari 0.5×10^5 hingga 3.0×10^5 ppm. Isyarat RF beralih dari 30.10 kHz menjadi 33.70 kHz seiring dengan peningkatan kepekatan amonia dari 1 hingga 10 ppm. Ringkasnya, SPF-ITO berjaya dihasilkan untuk peranti pensuisan-Q serta penderiaan.

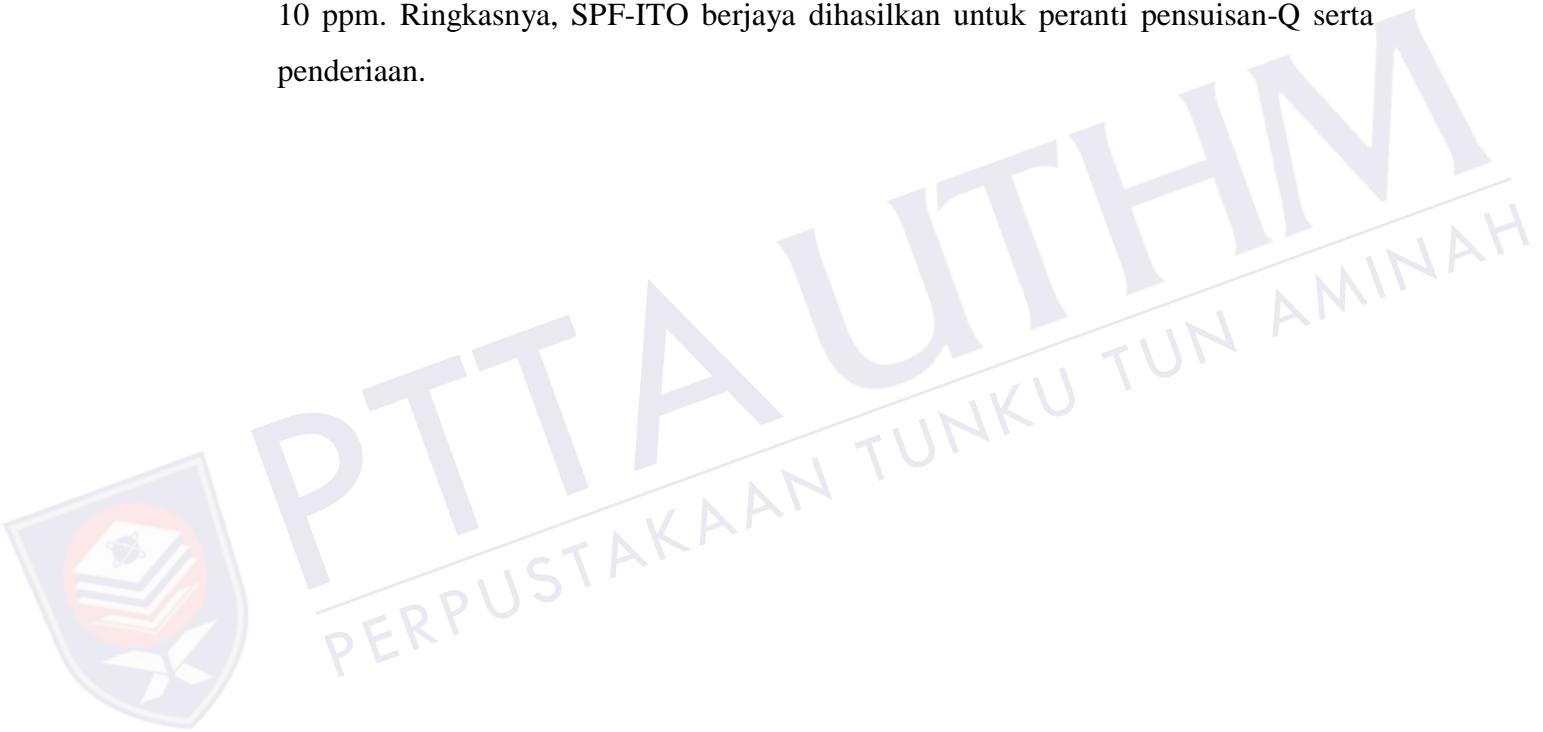


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LIST OF SYMBOLS AND ABBREVIATIONS

f	- light frequency operation
h	- plank constant
σ_{sg}	- absorption cross section at the ground state of the SA
τ_{se}	- absorber recovery time or excited state life time
α	- Absorption
I	- intensity of light
α_s	- saturable absorption
α_{ns}	- non-saturable absorption
I_{sat}	- saturation intensity.
T_R	- inverse of repetition rate
ε	- stored energy in the cavity
S_p	- the pulse shape factor
T_r	- cavity round-trip time
L	- length of a linear cavity
c	- speed of light
η	- light pulse energy efficiency
δ	- ratio between saturable and unsaturable cavity loss
N	- concentration of the material
E_P	- pulse energy
τ_p	- pulse width
ν_R	- phase locked frequency comb with constant mode-spacing
Δ_{vp}	- the spectral width of the envelope of the frequency comb
P_{avg}	- average power
n	- refractive index
$\gamma(\nu)$	- Lorentzian gain coefficient
$\Delta\nu$	- emission linewidth
ν_0	- central frequency

$\gamma_\beta(v)$	- Gaussian gain coefficient
β	- subset of frequency
Δv_s	- Lorentzian shape of width
N_o	- steady state population different
λ	- wavelength of light in the medium
τ_{sp}	- spontaneous lifetime
$\emptyset(t)$	- time-dependent phase of the wave
L	- electric field
a	- radius of the fiber core
ω	- state of oscillation frequency
ω_q	- set of frequencies
M	- number of modes in a step-index fiber with high v value
d	- film thickness
λ_o	- central wavelength
N_c	- group index
β_s	- slab region
β_c	- propagation constant in AWG
L	- thickness of the etalon filter
n_{eff}	- effective refractive index of the fiber core
Λ	- period of grating
λ_B	- reflected wavelength
ε	- molar extinction coefficient for intensity of light
C	- concentration of chemical
M_s	- concentration of the stock solution
V_s	- volume of the stock solution
M_d	- concentration of the diluted solution
V_d	- volume of the diluted solution.
AFM	- atomic force microscopy
APM	- additive pulse mode-locking
ASE	- amplified spontaneous emission
BFA	- Brillouin fiber amplifier
BP	- black phosphorus
CPM	- colliding pulse mode-locked

CCW	- counter clockwise
CNTs	- carbon nanotubes
CW	- continuous wave
CW	- Clockwise
DC	- direct current
DWDM	- dense wavelength division multiplexer
EDF	- erbium doped fiber
EDFA	- erbium doped fiber amplifier
EDFL	- erbium doped fiber laser
EDX	- energy-dispersive x-ray spectroscopy
FBG	- fiber bragg grating
FHWM	- full width half maximum
ITO	- indium tin oxide
KLM	- kerr lens mode-locking
LD	- laser diode
MBE	- molecular beam epitaxy
MOVPE	- metal-organic vapour phase epitaxy
MQWs	- multiquantum well
MWCNTs	- multi-walled carbon nanotubes
NALM	- nonlinear amplifying loop mirror
OSA	- optical spectrum analyser
PC	- polarization controller
PMMA	- Polymethylmethacrylate
PVA	- polyvinyl alchohol
RBW	- resolution bandwidth
RF	- radio frequency
RFA	- raman fiber amplifier
SA	- saturable absorber
SEM	- scanning electron microscope
SESAMs	- semiconductor saturable absorber mirrors
SMF	- single mode fiber
SMSR	- single mode suppression ratio
SNR	- signal noise ration

SOA	- semiconductor optical amplifier
SPF	- side-polished fiber
SWCNTs	- single-walled carbon nanotubes
TBF	- tunable band pass filter
TCOs	- transparent conducting oxides
TDF	- thulium doped fiber
THDF	- thulium holmium doped fiber
TIs	- topological insulators
TMDs	- transition metal dichalcogenides
UV-Vis-NIR	- ultraviolet-visible-near infrared
WDM	- wavelength division multiplexer



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LIST OF PUBLICATIONS

List of Publications:

1. **Zalkepali, N. U. H. H.**, Awang, N. A., Hadi, F. S. A., Azmi, A. N., & Zakaria, Z. (2018). Generation of Four-Wave Mixing in a Highly Non-Linear Optical Fiber Using a Tunable Dual Wavelength Fiber Laser Source. *Journal of Science and Technology*, 10(2).
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3. Mahmud, N., Eleena, N. N. H., Yuzaile, Y. R., **Zulkefli, N. U. H. H.**, Esa, F., Awang, N. A., & Zakaria, Z. (2018). Optimization of passively mode-locked erbium-doped fiber laser.
4. Yuzaile, Y.R., Awang, N.A., Zakaria, Z., **Zalkepali, N. U. H. H.**, Latif, A.A., Azmi, A.N., & Hadi, F.S. (2018). Graphite Saturable Absorber for Q-Switched Fiber Laser. . *International Journal of Engineering & Technology*, 7(4.30), 334-337.
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6. Yuzaile, Y. R., Awang, N. A., **Zalkepali, N. U. H. H.**, Zakaria, Z., Latif, A. A., Azmi, A. N., & Hadi, F. A. (2019). Pulse compression in Q-switched fiber laser by using platinum as saturable absorber. *Optik*, 179, 977-985.

7. Yuzale, Y. R., Zakaria, Z., **Zalkepali, N. U. H. H.**, Awang, N. A., Latif, A. A., & Mahmud, N. N. (2019, November). Q-switched erbium-doped fiber laser employing gold thin film saturable absorber. In *Journal of Physics: Conference Series* (Vol. 1371, No. 1, p. 012014). IOP Publishing.
8. Awang, N. A., Azmi, A. N., Yuzale, Y. R., **Zalkepali, N. U. H. H.**, & Zakaria, Z. (2019). Mode-locking soliton generation using platinum in figure-8 configuration. *Optical Fiber Technology*, 52, 101956.
9. Hadi, F.S.A., Zakaria, Z., Alsaady, M.M., Azmi, A.N., Mahmud, N.N.H.E.N., Yuzale, Y.R., **Zalkepali, N.U.H.H.** and Awang, N.A., (2019). Supercontinuum Generation by 50 m High Nonlinear Fiber in Double Ring Cavity. *Optik*, p.162995.
10. **Zalkepali, N. U. H. H.**, Awang, N. A., Yuzale, Y. R., Zakaria, Z., Latif, A. A., Ali, A. H., & Mahmud, N. N. H. E. (2020). Tunable indium tin oxide thin film as saturable absorber for generation of passively Q-switched pulse erbium-doped fiber laser. *Indian Journal of Physics*, 1-7.
11. **Zalkepali, N. U. H. H.**, Awang, N. A., Yuzale, Y. R., Zakaria, Z., Latif, A. A., & Ahmad, F., (2020) Graphene Nanoplatelets as saturable absorber for mode-locked fiber laser generation, *Journal of Advance Research in Dynamical & Control Systems*, 12(2), 602-607.
12. **Zalkepali, N. U. H. H.**, Awang, N. A., Latif, A. A., Zakaria, Z., Yuzale, Y. R., & Mahmud, N. N. H. E. N. (2020). Switchable Dual-wavelength Q-switched Fiber Laser based on Sputtered Indium Tin Oxide as Saturable Absorber. *Results in Physics*, 103187.
13. Yuzale, Y. R., Zakaria, Z., Awang, N. A., & **Zalkepali, N. U. H. H.** (2021). Plasma sputtered platinum saturable absorber with variable sputtering time for Q-switched erbium-doped fiber laser. *Optics & Laser Technology*, 136, 106525.

LIST OF AWARDS

List of Awards:

1. **Zalkepali, N. U. H. H.**, and Awang, N. A. Ammonia Q-switched pulse fiber sensor using Indium Tin Oxide coated side-polished fiber, Silver medal in Virtual International Research and Innovation Symposium and Exposition 2020 on 1st - 15th November 2020.
2. **Zalkepali, N. U. H. H.**, and Awang, N. A. Ammonia Q-switched pulse fiber sensor using Indium Tin Oxide coated side-polished fiber, Silver medal in The 2nd FAST Postgraduate Virtual Symposium 2020 on 21st December 2020.

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PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

REFERENCES

1. Rawicz, A. H. Theodore Harold Maiman and the invention of laser. In Photonics, Devices, and Systems IV. *International Society for Optics and Photonics*. 2008. 7138: 713802.
2. Kao, C. K. (1977). *Multiple access fiber optical bus communication system*. U. S. Patent 4, 017, 149.
3. Agrawal, G. P. (2020). Applications of nonlinear fiber optics. Academic press.
4. Shimizu, M., Suda, H., & Horiguchi, M. High-efficiency Nd-doped fibre lasers using direct-coated dielectric mirrors. *Electronics Letters*. 1987. 23(15): 768-769.
5. Mears, R. J., Reekie, L., Poole, S. B., & Payne, D. Neodymium-doped silica single-mode fibre lasers. *Electronics letters*. 1985. 21(17): 738-740.
6. Agrawal, G. (2001). *Applications of nonlinear fiber optics*. Elsevier.
7. Duling III, I. N., & Duling, I. N. (Eds.). (1995). Compact sources of ultrashort pulses (Vol. 18). Cambridge University Press.
8. Alcock, I., Ferguson, A., Hanna, D., & Tropper, A. Mode-locking of a neodymium-doped monomode fiber laser. *Electronics Letters*. 1986. 22(5): 268-269.
9. Alcock, I., Tropper, A., Ferguson, A., & Hanna, D. (1986). Q-switched operation of a neodymium-doped monomode fiber laser. *Electronics Letters*. 1986. 22(2): 84-85.
10. Keller, U., Miller, D. A. B., Boyd, G. D., Chiu, T. H., Ferguson, J. F., & Asom, M. T. Solid-state low-loss intracavity saturable absorber for Nd: YLF lasers: an antiresonant semiconductor Fabry–Perot saturable absorber. *Optics Letters*. 1992. 17(7): 505-507.
11. Jiang, M., Ma, H., Ren, Z., Chen, X., Long, J., Qi, M.,... Bai, J. A graphene Q-switched nanosecond Tm-doped fiber laser at 2 μm . *Laser Physics Letters*. 2013.10(5): 055103.

12. Chu, Z., Liu, J., Guo, Z., & Zhang, H. 2-μm passively Q-switched laser based on black phosphorus. *Optical Materials Express*. 2016. 6(7): 2374-2379.
13. Zhang, P., Chen, L., Chen, J., & Tu, Y. Material removal effect of microchannel processing by femtosecond laser. *Optics and Lasers in Engineering*. 2017. 98: 69-75.
14. Lei, X., Wieschendorf, C., Hao, L., Firth, J., Silvestri, L., Gross, S., ... & Fuerbach, A. Compact actively Q-switched laser for sensing applications. *Measurement*. 2021. 173: 108631.
15. Dongre, G., Rajurkar, A., Raut, R., & Jangam, S. Preparation of super-hydrophobic textures by using nanosecond pulsed laser. *Materials Today: Proceedings*. 2021. 42: 1145-1151.
16. Li, W., Liu, H., Zhang, J., Long, H., Feng, S., & Mao, Q. Q-switched fiber laser based on an acousto-optic modulator with injection seeding technique. *Applied optics*. 2016. 55(17): 4584-4588.
17. Ma, S., Yu, H., Zhang, H., Han, X., Lu, Q., Ma, C., ... & Wang, J. Efficient high repetition rate electro-optic Q-switched laser with an optically active langasite crystal. *Scientific reports*. 2016. 6: 30517.
18. Parali, U., Sheng, X., Minassian, A., Tawy, G., Sathian, J., Thomas, G. M., & Damzen, M. J. Diode-pumped Alexandrite laser with passive SESAM Q-switching and wavelength tunability. *Optics Communications*. 2018. 410: 970-976.
19. Fluck, R., Braun, B., Gini, E., Melchior, H., & Keller, U. Passively Q-switched 1.34-μm Nd: YVO₄ microchip laser with semiconductor saturable-absorber mirrors. *Optics Letters*. 1997. 22(13): 991-993.
20. Pollock, C. R., Brilliant, N. A., Gwin, D., Carrig, T. J., Alford, W. J., Heroux, J. B., ... & Meyer, J. R. Mode locked and Q-switched Cr: ZnSe laser using a semiconductor saturable absorbing mirror (SESAM). In *Advanced Solid-State Photonics Optical Society of America*. 2005. 252.
21. Zhang, H., Tang, D., Knize, R. J., Zhao, L., Bao, Q., & Loh, K. P. (2010). Graphene mode locked, wavelength-tunable, dissipative soliton fiber laser. *Applied Physics Letters*. 2010. 96(11): 111112-111112.
22. Du, J., Wang, Q., Jiang, G., Xu, C., Zhao, C., Xiang, Y., ... & Zhang, H. Ytterbium-doped fiber laser passively mode locked by few-layer

- molybdenum disulfide (MoS_2) saturable absorber functioned with evanescent field interaction. *Scientific reports*. 2014. 4: 6346.
23. Mak, K.F.; Sfeir, M.Y.; Wu, Y.; Lui, C.H.; Misewich, J.A.; Heinz, T.F. Measurement of the optical conductivity of graphene. *Phys. Rev. Lett.* 2008, 101, 196405.
 24. Tian, W., Yu, W., Shi, J., & Wang, Y. The property, preparation and application of topological insulators: a review. *Materials*. 2017. 10(7): 814.
 25. Liu, M., Liu, W., Liu, X., Wang, Y., & Wei, Z. Application of transition metal dichalcogenides in mid-infrared fiber laser. *Nano Select*. 2021. 2(1): 37-46.
 26. Liu, H., Neal, A. T., Zhu, Z., Luo, Z., Xu, X., Tománek, D., & Ye, P. D. Phosphorene: an unexplored 2D semiconductor with a high hole mobility. *ACS nano*. 2014. 8(4): 4033-4041.
 27. Island, J. O., Steele, G. A., van der Zant, H. S., & Castellanos-Gomez, A. Environmental instability of few-layer black phosphorus. *2D Materials*. 2015. 2(1): 011002.
 28. Cokrak, A. C., & Altuncu, A. Gain and noise figure performance of erbium doped fiber amplifiers (EDFA). *Istanbul University-Journal of Electrical & Electronics Engineering*. 2004. 4(2): 1111-1122.
 29. Becker, P. M., Olsson, A. A., & Simpson, J. R. (1999). *Erbium-doped fiber amplifiers: fundamentals and technology*. Elsevier.
 30. Baumeister, M., Dickmann, K., & Hoult, T. Fiber laser micro-cutting of stainless steel sheets. *Applied Physics A*. 2016. 85(2): 121-124.
 31. Kashiwagi, K., & Yamashita, S. Optical deposition of carbon nanotubes for fiber-based device fabrication. *Frontiers in Guided Wave Optics and Optoelectronics*. 2010. 647.
 32. Bao, Q., Zhang, H., Ni, Z., Wang, Y., Polavarapu, L., Shen, Z., ... & Loh, K. P. Monolayer graphene as a saturable absorber in a mode-locked laser. *Nano Research*. 2011. 4(3): 297-307.
 33. Zulkifli, A. Z. *Fabrication and characterisation of graphene oxide saturable absorber for Q-Switched fiber laser generation*. Ph.D. Thesis. University of Malaya; 2015.
 34. Shank, C. V., & Ippen, E. P. Subpicosecond kilowatt pulses from a mode-locked cw dye laser. *Applied Physics Letters*. 1974. 24(8): 373-375.

35. Ruddock, I. S., & Bradley, D. J. Bandwidth-limited subpicosecond pulse generation in mode-locked cw dye lasers. *Applied Physics Letters*. 1976. 29(5): 296-297.
36. Fork, R. L., Greene, B. I., & Shank, C. V. Generation of optical pulses shorter than 0.1 psec by colliding pulse mode locking. *Applied Physics Letters*. 1981. 38(9): 671-672.
37. Fermann, M. E., Galvanauskas, A., & Sucha, G. (Eds.). (2002). *Ultrafast Lasers: Technology and Applications* (Vol. 80). CRC Press.
38. Ippen, E. P., Haus, H. A., & Liu, L. Y. Additive pulse mode locking. *JOSA B*. 1989. 6(9): 1736-1745.
39. Mark, J., Liu, L. Y., Hall, K. L., Haus, H. A., & Ippen, E. P. Femtosecond pulse generation in a laser with a nonlinear external resonator. *Optics Letters*. 1989. 14(1): 48-50.
40. Krausz, F., Spielmann, C., Brabec, T., Wintner, E., & Schmidt, A. J. Self-starting additive-pulse mode locking of a Nd: glass laser. *Optics Letters*. 1990. 15(19): 1082-1084.
41. Haus, H. A., Fujimoto, J. G., & Ippen, E. P. Structures for additive pulse mode locking. *JOSA B*. 1991. 8(10): 2068-2076.
42. Spence, D. E., Kean, P. N., & Sibbett, W. 60-fsec pulse generation from a self-mode-locked Ti: sapphire laser. *Optics letters*. 1991. 16(1): 42-44.
43. Brabec, T., Spielmann, C., Curley, P. F., & Krausz, F. Kerr lens mode locking. *Optics Letters*. 1992. 17(18): 1292-1294.
44. Tolstik, N., Sorokin, E., & Sorokina, I. T. Kerr-lens mode-locked Cr: ZnS laser. *Optics Letters*. 2013. 38(3): 299-301.
45. Cerullo, G., Silvestri, S. D., & Magni, V. Self-starting Kerr-lens mode locking of a Ti: sapphire laser. *Optics Letters*. 1994. 19(14): 1040-1042.
46. Durfee, C. G., Storz, T., Garlick, J., Hill, S., Squier, J. A., Kirchner, M., Taft, G., Shea, K., Kapteyn, H., Murnane, M., & Backus, S. Direct diode-pumped Kerr-lens mode-locked Ti: sapphire laser. *Optics Express*. 2012. 20(13), 13677-13683.
47. Morgner, U., Kärtner, F. X., Cho, S. H., Chen, Y., Haus, H. A., Fujimoto, J. G., Ippen, E. P., Scheuer, V., Angelow, G., & Tschudi, T. Sub-two-cycle pulses from a Kerr-lens mode-locked Ti: sapphire laser. *Optics Letters*. 1999. 24(6), 411-413.

48. Keller, U., Miller, D. A. B., Boyd, G. D., Chiu, T. H., Ferguson, J. F., & Asom, M. T. Solid-state low-loss intracavity saturable absorber for Nd: YLF lasers: an antiresonant semiconductor Fabry–Perot saturable absorber. *Optics Letters*. 1992. 17(7): 505-507.
49. Hasan, T., Sun, Z., Wang, F., Bonaccorso, F., Tan, P. H., Rozhin, A. G., & Ferrari, A. C. Nanotube–polymer composites for ultrafast photonics. *Advanced Materials*. 2009. 21(38-39): 3874-3899.
50. Okhotnikov, O., Grudinin, A., & Pessa, M. Ultra-fast fibre laser systems based on SESAM technology: new horizons and applications. *New Journal of Physics*. 2004. 6(177): 1-22.
51. Burr, E., Pantouvaki, M., Fice, M., Gwilliam, R., Krysa, A., Roberts, J., & Seeds, A. Signal stability in periodically amplified fiber transmission systems using multiple quantum well saturable absorbers for regeneration. *Journal of Lightwave Technology*. 2006. 24(2): 747.
52. Isomaki, A., Vainionpaa, A. M., Lyytikainen, J., & Okhotnikov, O. G. Semiconductor mirror for optical noise suppression and dynamic dispersion compensation. *Quantum Electronics, IEEE Journal of*. 2003. 39(11): 1481-1485.
53. Akbari, R., Zhao, H., Fedorova, K. A., Rafailov, E. U., & Major, A. Quantum-dot saturable absorber and Kerr-lens mode-locked Yb: KGW laser with > 450 kW of peak power. *Optics letters*. 2016. 41(16): 3771-3774.
54. Zhang, Z., Torizuka, K., Itatani, T., Kobayashi, K., Sugaya, T., & Nakagawa, T. Self-starting mode-locked femtosecond forsterite laser with a semiconductor saturable-absorber mirror. *Optics letters*. 1997. 22(13): 1006-1008.
55. Tian, Z., Wang, B., Gao, C., Wu, Q., Xu, X., Xu, J., & Zhang, B. Passively Q-Switched Mode-Locking Nd:(Gd_{0.3}Y_{0.7})₂SiO₅ Laser Based on Semiconductor Saturable Absorber Mirror. *Journal of Russian Laser Research*. 2019. 40(1): 94-99.
56. Miller, J. M. *Optimizing and Applying Graphene as a Saturable Absorber for Generating Ultrashort Pulses*. Ph.D. Thesis. University of Colorado; 2011.
57. Wood, R. M. (2003). *Laser-induced damage of optical materials*. CRC Press.
58. Adams, L. E., Kintzer, E. S., Ramaswamy, M., Fujimoto, J. G., Keller, U., & Asom, M. T. Mode locking of a broad-area semiconductor laser with a

- multiplequantum-well saturable absorber. *Optics Letters*. 1993. 18(22): 1940-1942.
59. Steinmeyer, G., Sutter, D. H., Gallmann, L., Matuschek, N., & Keller, U. Frontiers in ultrashort pulse generation: pushing the limits in linear and nonlinear optics. *Science*. 1999. 286(5444): 1507-1512.
60. Guo, T., Nikolaev, P., Thess, A., Colbert, D. T., & Smalley, R. E. Catalytic growth of single-walled manotubes by laser vaporization. *Chemical Physics Letters*. 1995. 243(1): 49-54.
61. Journet, C., Maser, W. K., Bernier, P., Loiseau, A., De La Chapelle, M. L., Lefrant, D. L. S., Loiseau, A., Deniard, P., Lee, R., & Fischer, J. E. Large-scale production of single-walled carbon nanotubes by the electric-arc technique. *Nature*. 1997. 388(6644): 756-758.
62. Satishkumar, B. C., Govindaraj, A., Sen, R., & Rao, C. N. R. Single-walled nanotubes by the pyrolysis of acetylene-organometallic mixtures. *Chemical Physics Letters*. 1998. 293(1): 47-52.
63. Dai, H., Rinzler, A. G., Nikolaev, P., Thess, A., Colbert, D. T., & Smalley, R. E. Single-wall nanotubes produced by metal-catalyzed disproportionation of carbon monoxide. *Chemical Physics Letters*. 1996. 260(3): 471-475.
64. Set, S. Y., Yaguchi, H., Tanaka, Y., & Jablonski, M. Ultrafast fiber pulsed lasers incorporating carbon nanotubes. *Selected Topics in Quantum Electronics, IEEE Journal of*, 2004. 10(1): 137-146.
65. Kashiwagi, K., & Yamashita, S. Optical deposition of carbon nanotubes for fiber based device fabrication. *Frontiers in Guided Wave Optics and Optoelectronics*. 2010. 647.
66. Jost, O., Gorbunov, A. A., Pompe, W., Pichler, T., Friedlein, R., Knupfer, M., Reibold, M., Bauer, H. D., Dunsch, L., Golden, M. S., & Fink, J. Diameter grouping in bulk samples of single-walled carbon nanotubes from optical absorption spectroscopy. *Applied Physics Letters*, 1999. 75(15): 2217-2219.
67. Zheng, M., Jagota, A., Strano, M. S., Santos, A. P., Barone, P., Chou, S. G., Diner, B. A., Dresselhaus, M. S., McLean, R. S., Onoa, G. B., Samsonidze, G. G., Semke, E. D., Usrey, M., & Walls, D. J. Structure-based carbon nanotube sorting by sequence-dependent DNA assembly. *Science*, 2003. 302(5650): 1545-1548.

68. Kataura, H., Kumazawa, Y., Maniwa, Y., Umezu, I., Suzuki, S., Ohtsuka, Y., & Achiba, Y. Optical properties of single-wall carbon nanotubes. *Synthetic Metals*. 1999. 103(1): 2555-2558.
69. Sun, Z., Hasan, T., Torrisi, F., Popa, D., Privitera, G., Wang, F., Bonaccorso, F., Basko, D. M., & Ferrari, A. C. Graphene mode-locked ultrafast laser. *Acs Nano*. 2010. 4(2): 803-810.
70. Set, S. Y., Yaguchi, H., Tanaka, Y., & Jablonski, M. Laser mode locking using a saturable absorber incorporating carbon nanotubes. *Journal of lightwave Technology*. 2004. 22(1): 51.
71. Solodyankin, M. A., Obraztsova, E. D., Lobach, A. S., Chernov, A. I., Tausenev, A. V., Konov, V. I., & Dianov, E. M. Mode-locked 1.93 μm thulium fiber laser with a carbon nanotube absorber. *Optics letters*. 2008. 33(12): 1336-1338.
72. Wei, C., Lyu, Y., Li, Q., Kang, Z., Zhang, H., Qin, G., ... & Liu, Y. Wideband Tunable, Carbon Nanotube Mode-Locked Fiber Laser Emitting at Wavelengths Around 3- μm . *IEEE Photonics Technology Letters*. 2019. 31(11): 869-872.
73. Zhang, H., Tang, D., Knize, R. J., Zhao, L., Bao, Q., & Loh, K. P. Graphene mode locked, wavelength-tunable, dissipative soliton fiber laser. *Applied Physics Letters*. 2010. 96(11): 111112-111112.
74. Wallace, P. R. The band theory of graphite. *Physical Review*. 1947. 71(9): 622-634.
75. Novoselov, K. S., Geim, A. K., Morozov, S. V., Jiang, D., Zhang, Y., Dubonos, S.V., Grigorieva, I. V., & Firsov, A. A. Electric field effect in atomically thin carbon films. *Science*. 2004. 306(5696): 666-669.
76. Bonaccorso, F., Sun, Z., Hasan, T., & Ferrari, A. C. Graphene photonics and optoelectronics. *Nature photonics*. 2010. 4(9): 611.
77. Bao, Q., Zhang, H., Wang, Y., Ni, Z., Yan, Y., Shen, Z. X., Loh, K. P., & Tang, D.Y. Atomic-layer graphene as a saturable absorber for ultrafast pulsed lasers. *Advanced Functional Materials*. 2009. 19(19): 3077-3083.
78. Kumar, S., Anija, M., Kamaraju, N., Vasu, K. S., Subrahmanyam, K. S., Sood, A. K., & Rao, C. N. R. Femtosecond carrier dynamics and saturable absorption in graphene suspensions. *Applied Physics Letters*. 2009. 95(19): 191911.

79. Sun, Z., Popa, D., Hasan, T., Torrisi, F., Wang, F., Kelleher, E. J., Travers, J. C., Nicolosi, V., & Ferrari, A. C. A stable, wideband tunable, near transform limited, graphene-mode-locked, ultrafast laser. *Nano Research.* 2010. 3(9): 653-660.
80. Lee, C. C., Schibli, T. R., Acosta, G., & Bunch, J. S. Ultra-short optical pulse generation with single-layer graphene. *Journal of Nonlinear Optical Physics & Materials.* 2010. 19(04): 767-771.
81. Vasko, F. T. Saturation of interband absorption in graphene. *Physical Review B.* 2010. 82(24): 245422.
82. Xing, G., Guo, H., Zhang, X., Sum, T. C., & Huan, C. H. A. The Physics of ultrafast saturable absorption in graphene. *Optics Express.* 2010. 18(5): 4564-4573.
83. Zhang, H., Tang, D. Y., Zhao, L. M., Bao, Q. L., Loh, K. P., Lin, B., & Tjin, S. C. Compact graphene mode-locked wavelength-tunable erbium-doped fiber lasers: from all anomalous dispersion to all normal dispersion. *Laser Physics Letters.* 2010. 7(8): 591-596.
84. Zhang, H., Tang, D. Y., Zhao, L. M., Bao, Q. L., & Loh, K. P. Large energy mode locking of an erbium-doped fiber laser with atomic layer graphene. *Optics Express.* 2009. 17(20): 17630-17635.
85. Song, Y. W., Jang, S. Y., Han, W. S., & Bae, M. K. Graphene mode-lockers for fiber lasers functioned with evanescent field interaction. *Applied Physics Letters.* 2010. 96(5): 051122-051122.
86. Zhao, L. M., Tang, D. Y., Zhang, H., Wu, X., Bao, Q., & Loh, K. P. Dissipative soliton operation of an ytterbium-doped fiber laser mode locked with atomic multilayer graphene. *Optics Letters.* 2010. 35(21): 3622-3624.
87. Dawlaty, J. M., Shivaraman, S., Chandrashekhar, M., Rana, F., & Spencer, M. G. Measurement of ultrafast carrier dynamics in epitaxial graphene. *Applied Physics Letters.* 2008. 92: 042116.
88. Kumar, S., Anija, M., Kamaraju, N., Vasu, K. S., Subrahmanyam, K. S., Sood, A. K., & Rao, C. N. R. Femtosecond carrier dynamics and saturable absorption in graphene suspensions. *Applied physics letters.* 2009. 95(19): 191911.
89. Seibert, K., Cho, G. C., Kütt, W., Kurz, H., Reitze, D. H., Dadap, J. I., Ahn, H., Downer, M. C., & Malvezzi, A. M. Femtosecond carrier dynamics in graphite. *Physical Review B.* 1990. 42(5): 2842.

90. Sun, D., Wu, Z. K., Divin, C., Li, X., Berger, C., de Heer, W. A., First, P. N., & Norris, T. B. Ultrafast relaxation of excited Dirac fermions in epitaxial graphene using optical differential transmission spectroscopy. *Physical Review Letters*. 2008. 101(15): 157402.
91. Breusing, M., Ropers, C., & Elsaesser, T. Ultrafast carrier dynamics in graphite. *Physical Review Letters*. 2009. 102(8): 086809.
92. Casiraghi, C., Hartschuh, A., Lidorikis, E., Qian, H., Harutyunyan, H., Gokus, T., Novoselov, K. S., & Ferrari, A. C. Rayleigh imaging of graphene and graphene layers. *Nano Letters*. 2007. 7(9): 2711-2717.
93. Zhang, H., Tang, D., Knize, R. J., Zhao, L., Bao, Q., & Loh, K. P. Graphene mode locked, wavelength-tunable, dissipative soliton fiber laser. *Applied Physics Letters*. 2010. 96(11):111112
94. Hasan, M. Z., & Kane, C. L. Colloquium: topological insulators. *Reviews of modern physics*. 2010. 82(4): 3045.
95. Qi, X. L., & Zhang, S. C. Topological insulators and superconductors. *Reviews of Modern Physics*. 2011. 83(4): 1057.
96. Chen, Y. L., Analytis, J. G., Chu, J. H., Liu, Z. K., Mo, S. K., Qi, X. L., ... & Zhang, S. C. Experimental realization of a three-dimensional topological insulator, Bi_2Te_3 . *Science*. 2009. 325(5937): 178-181.
97. Fu, L., Kane, C. L., & Mele, E. J. Topological insulators in three dimensions. *Physical review letters*. 2007. 98(10): 106803.
98. Valla, T., Pan, Z. H., Gardner, D., Lee, Y. S., & Chu, S. Photoemission spectroscopy of magnetic and nonmagnetic impurities on the surface of the Bi_2Se_3 topological insulator. *Physical review letters*. 2012. 108(11): 117601.
99. Guo, Y., Liu, Z., & Peng, H. A roadmap for controlled production of topological insulator nanostructures and thin films. *Small*. 2015. 11(27): 3290-3305.
100. Kong, D., Dang, W., Cha, J. J., Li, H., Meister, S., Peng, H., ... & Cui, Y. Few-layer nanoplates of Bi_2Se_3 and Bi_2Te_3 with highly tunable chemical potential. *Nano letters*. 2010. 10(6): 2245-2250.
101. Khalil, L. *Ultrafast study of Dirac fermions in topological insulators*. Ph. D. Thesis. Paris Saclay; 2018.
102. Thomas, C. R. *The Surface and Interface Chemistry of $\text{Bi}_2(\text{Te},\text{Se})_3$ Topological Insulators*. Ph. D. Thesis. Princeton University; 2015.

103. Bernard, F., Zhang, H., Gorza, S. P., & Emplit, P. Towards mode-locked fiber laser using topological insulators. In *Nonlinear Photonics*. 2012. (pp. NTh1A-5). Optical Society of America.
104. Zhang, Y., He, K., Chang, C. Z., Song, C. L., Wang, L. L., Chen, X., ... & Shen, S. Q. Crossover of the three-dimensional topological insulator Bi_2Se_3 to the two-dimensional limit. *Nature Physics*. 2010. 6(8): 584.
105. Teweldebrhan, D., Goyal, V., Rahman, M., & Balandin, A. A. Atomically-thin crystalline films and ribbons of bismuth telluride. *Applied Physics Letters*. 2010. 96(5): 053107.
106. Peng, H., Lai, K., Kong, D., Meister, S., Chen, Y., Qi, X. L., ... & Cui, Y. Aharonov–Bohm interference in topological insulator nanoribbons. *Nature materials*. 2010. 9(3): 225.
107. Zhao, C., Zhang, H., Qi, X., Chen, Y., Wang, Z., Wen, S., & Tang, D. Ultra-short pulse generation by a topological insulator based saturable absorber. *Applied Physics Letters*. 2012. 101(21): 211106.
108. Lee, J., Koo, J., Chi, C., & Lee, J. H. All-fiberized, passively Q-switched 1.06 μm laser using a bulk-structured Bi_2Te_3 topological insulator. *Journal of Optics*. 2014. 16(8): 085203
109. Zalkepali, N. U. H. H., Awang, N. A., Yuzaile, Y. R., Latif, A. A., Ahmad, F., Azmi, A. N., ... & Zakaria, Z. Passively Q-Switched Pulse Erbium Doped Fiber Laser Using Antimony (III) Telluride (Sb_2Te_3) thin Film as Saturable Absorber. *International Journal of Engineering & Technology*. 2018. 7(4.30): 313-316.
110. Liu, H., Zheng, X. W., Liu, M., Zhao, N., Luo, A. P., Luo, Z. C., ... & Wen, S. C. Femtosecond pulse generation from a topological insulator mode-locked fiber laser. *Optics express*. 2014. 22(6): 6868-6873.
111. Kim, N., Lee, P., Kim, Y., Kim, J. S., Kim, Y., Noh, D. Y., ... & Kim, K. S. Persistent topological surface state at the interface of Bi_2Se_3 film grown on patterned graphene. *ACS nano*. 2014. 8(2): 1154-1160.
112. Woodward, R. I., & Kelleher, E. J. 2D saturable absorbers for fibre lasers. *Applied Sciences*. 2015. 5(4): 1440-1456.
113. Mao, D., Wang, Y., Ma, C., Han, L., Jiang, B., Gan, X., ... & Zhao, J. WS_2 mode-locked ultrafast fiber laser. *Scientific reports*. 2015. 5: 7965.

114. Mak, K. F., Lee, C., Hone, J., Shan, J., & Heinz, T. F. Atomically thin MoS₂: a new direct-gap semiconductor. *Physical review letters*. 2010. 105(13): 136805.
115. Tongay, S., Zhou, J., Ataca, C., Lo, K., Matthews, T. S., Li, J., ... & Wu, J. Thermally driven crossover from indirect toward direct bandgap in 2D semiconductors: MoSe₂ versus MoS₂. *Nano letters*. 2012. 12(11): 5576-5580.
116. Kuc, A., Zibouche, N., & Heine, T. Influence of quantum confinement on the electronic structure of the transition metal sulfide TS₂. *Physical Review B*. 2011. 83(24): 245213.
117. Xia, F., Wang, H., & Jia, Y. Rediscovering black phosphorus as an anisotropic layered material for optoelectronics and electronics. *Nature communications*. 2014. 5(1): 1-6.
118. Churchill, H. O., & Jarillo-Herrero, P. Two-dimensional crystals: Phosphorus joins the family. *Nature nanotechnology*. 2014. 9(5): 330-331.
119. Baba, M., Nakamura, Y., Takeda, Y., Shibata, K., Morita, A., Koike, Y., & Fukase, T. Hall effect and two-dimensional electron gas in black phosphorus. *Journal of Physics: Condensed Matter*. 1992. 4(6): 1535.
120. Nishii, T., Maruyama, Y., Inabe, T., & Shirotani, I. Synthesis and characterization of black phosphorus intercalation compounds. *Synthetic Metals*. 1987. 18(1-3): 559-564.
121. Castellanos-Gomez, A., Vicarelli, L., Prada, E., Island, J. O., Narasimha-Acharya, K. L., Blanter, S. I., ... & Zandbergen, H. W. Isolation and characterization of few-layer black phosphorus. *2D Materials*. 2014. 1(2): 025001.
122. Liu, H., Neal, A. T., Zhu, Z., Luo, Z., Xu, X., Tománek, D., & Ye, P. D. Phosphorene: an unexplored 2D semiconductor with a high hole mobility. *ACS nano*. 2014. 8(4): 4033-4041.
123. Cai, Y., Zhang, G., & Zhang, Y. W. Layer-dependent band alignment and work function of few-layer phosphorene. *Scientific reports*. 2014. 4: 6677.
124. Zhang, S., Yang, J., Xu, R., Wang, F., Li, W., Ghufran, M., ... & Lu, Y. Extraordinary photoluminescence and strong temperature/angle-dependent Raman responses in few-layer phosphorene. *ACS nano*. 2014. 8(9): 9590-9596.

125. Tran, V., Soklaski, R., Liang, Y., & Yang, L. Layer-controlled band gap and anisotropic excitons in few-layer black phosphorus. *Physical Review B*. 2014. 89(23): 235319.
126. Park, K., Lee, J., Lee, Y. T., Choi, W. K., Lee, J. H., & Song, Y. W. Black phosphorus saturable absorber for ultrafast mode-locked pulse laser via evanescent field interaction. *Annalen der Physik*. 2015. 527(11-12): 770-776.
127. Li, D., Jussila, H., Karvonen, L., Ye, G., Lipsanen, H., Chen, X., & Sun, Z. Polarization and thickness dependent absorption properties of black phosphorus: new saturable absorber for ultrafast pulse generation. *Scientific reports*. 2015. 5: 15899.
128. Hanlon, D., Backes, C., Doherty, E., Cucinotta, C. S., Berner, N. C., Boland, C., ... & Zhang, S. Liquid exfoliation of solvent-stabilized few-layer black phosphorus for applications beyond electronics. *Nature communications*. 2015. 6(1): 1-11.
129. Sotor, J., Sobon, G., Macherzynski, W., Paletko, P., & Abramski, K. M. Black phosphorus saturable absorber for ultrashort pulse generation. *Applied Physics Letters*. 2015. 107(5): 051108.
130. Qin, Z., Xie, G., Zhang, H., Zhao, C., Yuan, P., Wen, S., & Qian, L. Black phosphorus as saturable absorber for the Q-switched Er: ZBLAN fiber laser at 2.8 μm . *Optics express*. 2015. 23(19): 24713-24718.
131. Qin, Z., Xie, G., Zhao, C., Wen, S., Yuan, P., & Qian, L. Mid-infrared mode-locked pulse generation with multilayer black phosphorus as saturable absorber. *Optics letters*. 2016. 41(1): 56-59.
132. Rashid, F. A. A., Azzuhri, S. R., Salim, M. A. M., Shaharuddin, R. A., Ismail, M. A., Ismail, M. F., ... & Ahmad, H. Using a black phosphorus saturable absorber to generate dual wavelengths in a Q-switched ytterbium-doped fiber laser. *Laser Physics Letters*. 2016. 13(8): 085102.
133. Mu, H., Lin, S., Wang, Z., Xiao, S., Li, P., Chen, Y., ... & Fan, D. Black phosphorus–polymer composites for pulsed lasers. *Advanced Optical Materials*. 2015. 3(10): 1447-1453.
134. Li, S., Yin, Y., Lewis, E., Garrell, G., Rosol, A. H. A., Latiff, A. A., ... & Wang, P. All fibre Q-switched Thulium-doped fibre laser incorporating Thulium–Holmium co-doped fibre as a saturable absorber. *Optics Communications*. 2019. 450: 160-165.

135. Tsai, T. Y., Fang, Y. C., & Hung, S. H. Passively Q-switched erbium all-fiber lasers by use of thulium-doped saturable-absorber fibers. *Optics express.* 2010. 18(10): 10049-10054.
136. Tao, M., Wu, J., Peng, J., Wu, Y., Yang, P., & Ye, X. Experimental demonstration of an Er-doped fiber ring laser mode-locked with a Tm–Ho co-doped fiber saturable absorber. *Laser Physics.* 2013. 23(8): 085102.
137. Latiff, A. A., Kadir, N. A., Ismail, E. I., Shamsuddin, H., Ahmad, H., & Harun, S. W. All-fiber dual-wavelength Q-switched and mode-locked EDFL by SMF-THDF-SMF structure as a saturable absorber. *Optics Communications.* 2017. 389: 29-34.
138. Jackson, S. D. Passively Q-switched Tm 3+-doped silica fiber lasers. *Applied optics.* 2007. 46(16): 3311-3317.
139. Naik, G. V., Shalaev, V. M., & Boltasseva, A. Alternative plasmonic materials: beyond gold and silver. *Advanced Materials.* 2013. 25(24): 3264-3294.
140. Kanehara, M., Koike, H., Yoshinaga, T., & Teranishi, T. Indium tin oxide nanoparticles with compositionally tunable surface plasmon resonance frequencies in the near-IR region. *Journal of the American Chemical Society.* 2009. 131(49): 17736-17737.
141. Alam, M. Z., De Leon, I., & Boyd, R. W. Large optical nonlinearity of indium tin oxide in its epsilon-near-zero region. *Science.* 2016. 352(6287): 795-797.
142. Guo, J., Zhang, H., Li, Z., Sheng, Y., Guo, Q., Han, X., ... & Jiang, S. Dark solitons in erbium-doped fiber lasers based on indium tin oxide as saturable absorbers. *Optical Materials.* 2018. 78: 432-437.
143. Guo, J., Zhang, H., Zhang, C., Li, Z., Sheng, Y., Li, C., ... & Jiang, S. Indium tin oxide nanocrystals as saturable absorbers for passively Q-switched erbium-doped fiber laser. *Optical Materials Express.* 2017. 7(10): 3494-3502.
144. Guo, Q., Cui, Y., Yao, Y., Ye, Y., Yang, Y., Liu, X., ... & Hosono, H. Exploiting ITO colloidal nanocrystals for ultrafast pulse generation. 2017. *arXiv preprint arXiv:1701.07586.*
145. Guo, Q., Pan, J., Li, D., Shen, Y., Han, X., Gao, J., ... & Jiang, S. Versatile mode-locked operations in an Er-doped fiber laser with a film-type indium tin oxide saturable absorber. *Nanomaterials.* 2019. 9(5): 701.

146. Ismail M, Ahmad F, Harun S, Arof H, Ahmad H. A Q-switched erbium-doped fiber laser with a graphene saturable absorber. *Laser Physics Letters*. 2013. 10(2):025102.
147. Harun, S. W., Ismail, M. A., Ahmad, F., Ismail, M. F., Nor, R. M., Zulkepely, N. R., & Ahmad, H. A Q-switched erbium-doped fiber laser with a carbon nanotube based saturable absorber. *Chinese Physics Letters*. 2012. 29(11): 114202.
148. Harun, S. W., Ahmad, H., Ismail, M. A., & Ahmad, F. Q-switched and soliton pulses generation based on carbon nanotubes saturable absorber. In *2013 Saudi International Electronics, Communications and Photonics Conference*. 2013. 1-4.
149. Kadir, N. A. A., Ismail, E. I., Latiff, A. A., Ahmad, H., Arof, H., & Harun, S. W. Transition metal dichalcogenides (WS_2 and MoS_2) saturable absorbers for mode-locked erbium-doped fiber lasers. *Chinese Physics Letters*. 2017. 34(1): 014202.
150. Liu, H., Song, W., Yu, Y., Jiang, Q., Pang, F., & Wang, T. Black Phosphorus-Film with Drop-Casting Method for High-Energy Pulse Generation From Q-Switched Er-Doped Fiber Laser. *Photonic Sensors*. 2019. 9(3): 239-245.
151. Jiang, G., Zhou, Y., Wang, L., & Chen, Y. PMMA Sandwiched Bi_2Te_3 Layer as a Saturable Absorber in Mode-Locked Fiber Laser. *Advances in Condensed Matter Physics*. 2018.
152. Chang, Y. M., Kim, H., Lee, J. H., & Song, Y. W. Multilayered graphene efficiently formed by mechanical exfoliation for nonlinear saturable absorbers in fiber mode-locked lasers. *Applied Physics Letters*. 2010. 97(21): 211102.
153. Lau, K. Y., Latif, A. A., Bakar, M. A., Muhammad, F. D., Omar, M. F., & Mahdi, M. A. Mechanically deposited tungsten disulfide saturable absorber for low-threshold Q-switched erbium-doped fiber laser. *Applied Physics B*. 2017. 123(8): 221.
154. Wu, K., Zhang, X., Wang, J., & Chen, J. 463-MHz fundamental mode-locked fiber laser based on few-layer MoS_2 saturable absorber. *Optics letters*. 2015. 40(7): 1374-1377.
155. Mao, D., Li, M., Cui, X., Zhang, W., Lu, H., Song, K., & Zhao, J. Stable high-power saturable absorber based on polymer-black-phosphorus films. *Optics Communications*. 2018. 406: 254-259.

156. Guo, B., Yao, Y., Yang, Y. F., Yuan, Y. J., Wang, R. L., Wang, S. G., ... & Yan, B. Topological insulator: Bi₂Se₃/polyvinyl alcohol film-assisted multi-wavelength ultrafast erbium-doped fiber laser. *Journal of Applied Physics*. 2015. 117(6): 063108.
157. Xu, J., Wu, S., Liu, J., Wang, Q., Yang, Q. H., & Wang, P. Nanosecond-pulsed erbium-doped fiber lasers with graphene saturable absorber. *Optics Communications*. 2012. 285(21-22): 4466-4469.
158. Nakazawa, M., Nakahara, S., Hirooka, T., Yoshida, M., Kaino, T., & Komatsu, K. Polymer saturable absorber materials in the 1.5 μm band using poly-methyl-methacrylate and polystyrene with single-wall carbon nanotubes and their application to a femtosecond laser. *Optics letters*. 2006. 31(7): 915-917.
159. Luo, Z., Huang, Y., Weng, J., Cheng, H., Lin, Z., Xu, B., ... & Xu, H. 1.06 μm Q-switched ytterbium-doped fiber laser using few-layer topological insulator Bi₂Se₃ as a saturable absorber. *Optics express*. 2013. 21(24): 29516-29522.
160. Luo, Z. C., Liu, M., Guo, Z. N., Jiang, X. F., Luo, A. P., Zhao, C. J., ... & Zhang, H. Microfiber-based few-layer black phosphorus saturable absorber for ultra-fast fiber laser. *Optics express*. 2015. 23(15): 20030-20039.
161. Wang, Q., Chen, T., Zhang, B., Li, M., Lu, Y., & Chen, K. P. All-fiber passively mode-locked thulium-doped fiber ring laser using optically deposited graphene saturable absorbers. *Applied Physics Letters*. 2013. 102(13): 131117.
162. Nicholson, J. W., Windeler, R. S., & DiGiovanni, D. J. Optically driven deposition of single-walled carbon-nanotube saturable absorbers on optical fiber end-faces. *Optics express*. 2007. 15(15). 9176-9183.
163. Kassani, S. H., Khazainezhad, R., Jeong, H., Nazari, T., Yeom, D. I., & Oh, K. All-fiber Er-doped Q-switched laser based on tungsten disulfide saturable absorber. *Optical Materials Express*. 2015. 5(2): 373-379.
164. Yamashita, S. A tutorial on nonlinear photonic applications of carbon nanotube and graphene. *Journal of lightwave technology*. 2011. 30(4): 427-447.
165. Wang, J., Xing, Y., Chen, L., Li, S., Jia, H., Zhu, J., & Wei, Z. Passively Q-switched Yb-doped all-fiber laser with a black phosphorus saturable absorber. *Journal of Lightwave Technology*. 2018. 36(10): 2010-2016.
166. Steinberg, D., Gerosa, R. M., Pellicer, F. N., Zapata, J. D., Domingues, S. H., de Souza, E. A. T., & Saito, L. A. Graphene oxide and reduced graphene oxide

- as saturable absorbers onto D-shaped fibers for sub 200-fs EDL mode-locking. *Optical Materials Express*. 2018. 8(1): 144-156.
167. Rusdi, M. F. M., Mahyuddin, M. B. H., Latiff, A. A., Ahmad, H., & Harun, S. W. Q-Switched Erbium-Doped Fiber Laser Using Cadmium Selenide Coated onto Side-Polished D-Shape Fiber as Saturable Absorber. *Chinese Physics Letters*. 2018. 35(10): 10420.
 168. Koo, J., Jeong, K., Yu, B. A., & Shin, W. Evanescent field interaction with Fe₃O₄ nano-particle for passively Q-switched thulium-doped fiber laser at 1.94 μm. *Optics & Laser Technology*. 2019. 119: 105579.
 169. Ahmad, M. T., Rusdi, M. F. M., Jafry, A. A. A., Latiff, A. A., Zakaria, R., Zainuddin, N. A. M., ... & Harun, S. W. Q-switched erbium-doped fiber laser using silver nanoparticles deposited onto side-polished D-shaped fiber by electron beam deposition method. *Optical Fiber Technology*. 2019. 53:101997.
 170. Mkrtchyan, A. A., Gladush, Y. G., Galiakhmetova, D., Yakovlev, V., Ahtyamov, V. T., & Nasibulin, A. G. Dry-transfer technique for polymer-free single-walled carbon nanotube saturable absorber on a side polished fiber. *Optical Materials Express*. 2019. 9(4): 1551-1561.
 171. Smith, G. The early laser years at Hughes Aircraft Company. *IEEE journal of quantum electronics*. 1984. 20(6): 577-584.
 172. Singer, J. R. (1961). Advances in quantum electronics. In *Advances in Quantum Electronics*.
 173. Collins, R. J., & Kisliuk, P. Control of population inversion in pulsed optical masers by feedback modulation. *Journal of Applied Physics*. 1962. 33(6): 2009-2011.
 174. McClung, F. J., & Hellwarth, R. W. Giant optical pulsations from ruby. *Journal of Applied Physics*. 1962. 33(3): 828-829.
 175. Digonnet, M. J. (2002). *Rare-Earth-Doped Fiber Lasers and Amplifiers*, Revised and Expanded: New York, USA: CRC Press.
 176. Rodenchuk, C. *Carbon nano-material based saturable absorbers and their application to mode-locked lasers*. Ph.D. Thesis. McGill University; 2011.

177. El-Sherif, A. F., & King, T. A. High-energy, high-brightness Q-switched Tm³⁺-doped fiber laser using an electro-optic modulator. *Optics communications*. 2003. 218(4-6): 337-344.
178. Wang, C., Zang, H., Li, X., Lu, Y., & Zhu, X. LD-pumped high repetition rate Q-switched Nd: YVO₄ laser by using La₃Ga₅SiO₁₄ single crystal electro-optic modulator. *Chinese Optics Letters*. 2006. 4(6): 329-331.
179. Roth, M., Tseitlin, M., & Angert, N. Oxide crystals for electro-optic Q-switching of lasers. *Glass physics and chemistry*. 2005. 31(1): 86-95.
180. Cuadrado-Laborde, C., Delgado-Pinar, M., Torres-Peiró, S., Díez, A., & Andrés, M. V. Q-switched all-fibre laser using a fibre-optic resonant acousto-optic modulator. *Optics communications*. 2007. 274(2): 407-411.
181. Jabczyński, J. K., Zendzian, W., & Kwiatkowski, J. Q-switched mode-locking with acousto-optic modulator in a diode pumped Nd: YVO₄ laser. *Optics express*. 2006. 14(6): 2184-2190.
182. Bromley, L. J., & Hanna, D. C. Single-frequency Q-switched operation of a diode-laser-pumped Nd: YAG ring laser using an acousto-optic modulator. *Optics letters*. 1991. 16(6): 378-380.
183. Hjelme, D. R., & Mickelson, A. R. Theory of timing jitter in actively mode locked lasers. *IEEE Journal of Quantum Electronics*. 1992. 28(6): 1594-1606.
184. Zayhowski, J., & Dill, C. Coupled-cavity electro-optically Q-switched Nd: YVO₄ microchip lasers. *Optics Letters*. 1995. 20(7): 716-718.
185. Eichhorn, M., & Jackson, S. D. High-pulse-energy actively Q-switched Tm 3+-doped silica 2-μm fiber laser pumped at 792 nm. *Optics Letters*. 2007. 32(19): 2780-2782.
186. Zayhowski, J. J., & Kelley, P. L. Optimization of Q-switched lasers. *IEEE Journal of Quantum Electronics*. 1991. 27(9): 2220-2225.
187. Spühler, G., Paschotta, R., Fluck, R., Braun, B., Moser, M., Zhang, G., . . . Keller, U. Experimentally confirmed design guidelines for passively Q-switched microchip lasers using semiconductor saturable absorbers. *Journal of Optical Society of America B*. 1999. 16(3): 376-388.
188. Chen, Y.-F., Tsai, S., & Wang, S. High-power diode-pumped Q-switched and mode-locked Nd:YVO₄ laser with a Cr⁴⁺ : YAG saturable absorber. *Optics Letters*. 2000. 25(19): 1442-1444.

189. Tsai, T.-Y., & Birnbaum, M. Co²⁺ : ZnS and Co²⁺ : ZnSe saturable absorber Q switches. *Journal of Applied Physics*. 2000. 87(1): 25-29.
190. Jackson, S. D. Passively Q-switched Tm³⁺-doped silica fiber lasers. *Applied Optics*. 2007. 46(16): 3311-3317.
191. Kurkov, A. S., Sholokhov, E. M., Tsvetkov, V. B., Marakulin, A. V., Minashina, L., Medvedkov, O. I., & Kosolapov, A. F. Holmium fibre laser with record quantum efficiency. *Quantum Electronics*. 2011. 41(6): 492-494.
192. Keller, U. Recent developments in compact ultrafast lasers. *Nature*. 2003. 424(6950): 831-838.
193. Herda, R., Kivistö, S., & Okhotnikov, O. G. Dynamic gain induced pulse shortening in Q-switched lasers. *Optics Letters*. 2008. 33(9): 1011-1013.
194. Zaykowski, J., & Dill, C. Diode-pumped passively Q-switched picosecond microchip lasers. *Optics Letters*. 1994. 19(18): 1427-1429.
195. Huang, S.-L., Tsui, T.-Y., Wang, C.-H., & Kao, F.-J. Timing jitter reduction of a passively Q-switched laser. *Japanese Journal of Applied Physics*. 1999. 38(3A): L239.
196. Bellemare, A. Continuous-wave silica-based erbium-doped fibre lasers. *Progress in Quantum Electronics*. 2003. 27(4), 211-266.
197. Desurvire, E. (1994). Erbium-Doped Fiber Amplifiers. Canada: John Wiley and Sons, Inc. 770.
198. Siegman, A.E., *Lasers*: University Science Books. 1986.
199. Saleh, B.E.A., *Photonic*. Hoboken, New Jersey: John Wiley & Sons. 2007.
200. Saleh, B.E.A. and M.C. Teich, *Fundamentals of photonics*. Wiley-Interscience. 2007.
201. Tanaka, S., Inamoto, K., Yokosuka, H., Somatomo, H., & Takahashi, N. Multi-wavelength tunable fiber laser using SOA: application to fiber Bragg grating vibration sensor array. In *SENSORS*, 2007. 411-414.
202. Tang, M., Minamide, H., Wang, Y., Notake, T., Ohno, S., & Ito, H. Tunable terahertz-wave generation from DAST crystal pumped by a monolithic dual-wavelength fiber laser. *Optics express*. 2011. 19(2): 779-786.
203. Piprek, J., Hutchinson, J. M., Henness, J. A., Masanovic, M. L., & Coldren, L. A. Saturation analysis of a monolithic wavelength converter. In *Physics and Applications of Optoelectronic Devices*. 2004. 5594:102-109.

204. Zilkie, A. J., Meier, J., Mojahedi, M., Poole, P. J., Barrios, P., Poitras, D., ... & Smith, P. W. Carrier Dynamics of Quantum-Dot, Quantum-Dash, and Quantum-Well Semiconductor Optical Amplifiers Operating at 1.55 μm . *IEEE Journal of Quantum Electronics*. 2007. 43(11): 982-991.
205. Vlachos, K., Bintjas, C., Pleros, N., & Avramopoulos, H. Ultrafast semiconductor-based fiber laser sources. *IEEE Journal of selected topics in quantum electronics*. 2004. 10(1): 147-154.
206. Kim, B., Han, J., & Chung, Y. Tunable and switchable multi-wavelength fiber laser based on semiconductor optical amplifier and twin-core photonic crystal fiber. In *Optical Components and Materials IX*. 2012. 8257: 82570F.
207. Adachi, S., Kawaguchi, H., Takahei, K., & Noguchi, Y. InGaAsP/InP buried-heterostructure lasers ($\lambda = 1.5 \mu\text{m}$) with chemically etched mirrors. *Journal of Applied Physics*. 1981. 52(9): 5843-5845.
208. Adachi, S. Material parameters of $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}$ and related binaries. *Journal of Applied Physics*. 1982. 53(12): 8775-8792.
209. Adachi, S. Optical dispersion relations for GaP, GaAs, GaSb, InP, InAs, InSb, $\text{Al}_x\text{Ga}_{1-x}\text{As}$, and $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}$. *Journal of Applied Physics*. 1989. 66(12): 6030-6040.
210. Broberg, B., & Lindgren, S. Refractive index of $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}$ layers and InP in the transparent wavelength region. *Journal of Applied Physics*. 1984. 55(9): 3376-3381.
211. Henry, C. H., Johnson, L., Logan, R., & Clarke, D. Determination of the refractive index of InGaAsP epitaxial layers by mode line luminescence spectroscopy. *IEEE journal of quantum electronics*. 1985. 21(12): 1887-1892.
212. Fiedler, F., & Schlachetzki, A. Optical parameters of InP-based waveguides. *Solid-state electronics*. 1987. 30(1): 73-83.
213. Connelly, M. J. (2007). *Semiconductor optical amplifiers*. Springer Science & Business Media.
214. Gustafson, T. K., Taran, J. P., Haus, H. A., Lifsitz, J. R., & Kelley, P. L. Self-modulation, self-steepening, and spectral development of light in small-scale trapped filaments. *Physical Review*. 1969. 177(1): 306.
215. Cubeddu, R., Polloni, R., Sacchi, C. A., & Svelto, O. Self-phase modulation and "rocking" of molecules in trapped filaments of light with picosecond pulses. *Physical Review A*. 1970. 2(5): 1955.

216. Alfano, R. R., & Shapiro, S. L. Direct distortion of electronic clouds of rare-gas atoms in intense electric fields. *Physical Review Letters*. 1970. 24(22): 1217.
217. Shimizu, F. Frequency broadening in liquids by a short light pulse. *Physical Review Letters*. 1967. 19(19): 1097.
218. Ippen, E. P., Shank, C. V., & Gustafson, T. K. Self-phase modulation of picosecond pulses in optical fibers. *Applied Physics Letters*. 1974. 24(4): 190-192.
219. Stolen, R. H., & Lin, C. Self-phase-modulation in silica optical fibers. *Physical Review A*. 1978. 17(4): 1448.
220. Genty, G., Coen, S., & Dudley, J. M. Fiber supercontinuum sources. *JOSA B*. 2007. 24(8): 1771-1785.
221. Stolen, R., & Lin, C. Self-phase-modulation in silica optical fibers. *Physical Review A*. 1978. 17(4): 1448-1453.
222. Agrawal, G. P. (2007). *Nonlinear fiber optics*. United States of America: Academic press.
223. Basch, E. B. (1987). *Optical-fiber transmission*. England: Prentice Hall.
224. Kikuchi, N., & Sasaki, S. Analytical evaluation technique of self-phase-modulation effect on the performance of cascaded optical amplifier systems. *Journal of Lightwave Technology*. 1995.13(5): 868-878.
225. Singh, S. P., Gangwar, R., & Singh, N. Nonlinear scattering effects in optical fibers. *Progress In Electromagnetics Research*. 2007. 74: 379-405.
226. Antoncini, C. (2006). Ultrashort laser pulses. *University of Reading, Department of Physics*
227. Chang, F. (2019). *Datacenter connectivity technologies: principles and practice*. Stylus Publishing, LLC.
228. Bagwell, P. F. Mode Competition in Gas and Semiconductor Lasers. 2003. *arXiv preprint physics/0309045*.
229. Smith, A. V., & Smith, J. J. Mode competition in high power fiber amplifiers. *Optics express*. 2011. 19(12): 11318-11329.
230. Feng, X., Tam, H. Y., & Wai, P. K. A. Stable and uniform multiwavelength erbium-doped fiber laser using nonlinear polarization rotation. *Optics express*. 2006. 14(18): 8205-8210.

231. Frenkel, A., & Lin, C. Angle-tuned etalon filters for optical channel selection in high density wavelength division multiplexed systems. *Journal of lightwave technology*. 1989. 7(4): 615-624.
232. Erdogan, T. Fiber grating spectra. *Journal of Lightwave Technology*. 1997. 15(8): 1277-1294.
233. Lin, C. Y., Chern, G. W., & Wang, L. A. Periodical corrugated structure for forming sampled fiber Bragg grating and long-period fiber grating with tunable coupling strength. *Journal of Lightwave Technology*. 2001. 19(8): 1212-1220.
234. Hill, K. O., & Meltz, G. Fiber Bragg grating technology fundamentals and overview. *Journal of Lightwave Technology*. 1997. 15(8): 1263-1276.
235. Zhang, C., Liu, L., Liu, Z., Zheng, S., Zhao, R., & Jian, S. Tunable multi-wavelength fiber laser based on a polarization-maintaining erbium-doped fiber and a polarization controller. *Optics Communications*. 2011. 284(10-11): 2550-2553.
236. Udd, E., & Spillman Jr, W. B. (Eds.). (2011). *Fiber optic sensors: an introduction for engineers and scientists*. John Wiley & Sons.
237. Zhang, Q., Chang, J., Wang, Q., Wang, Z., Wang, F., & Qin, Z. Acousto-optic Q-switched fiber laser-based intra-cavity photoacoustic spectroscopy for trace gas detection. *Sensors*. 2018. 18(1): 42.
238. Krzempek, K., Dudzik, G., & Abramski, K. Photothermal spectroscopy of CO₂ in an intracavity mode-locked fiber laser configuration. *Optics Express*. 2018. 26(22): 28861-28871.
239. Cooper, D. E. and Martinelli, R. U. Near-infrared diode lasers monitor molecular species. *Laser Focus World*. 1992. 28(11): 133-146.
240. Gratten, K. T. V., & Meggitt, B. T. (Eds.). (1999). *Optical Fibre Sensor Technology: Chemical and environmental sensing*. Kluwer.
241. Wolfbeis, O. S. (2003). A review on milestones in opt (r) ode technology until the year 2000. *Optical sensors for industrial, environmental and clinical applications*. Springer, Berlin, 1-34.
242. Tao, S., Winstead, C. B., Singh, J. P., & Jindal, R. Porous solgel fiber as a transducer for highly sensitive chemical sensing. *Optics letters*. 2002. 27(16): 1382-1384.

243. MacCraith, B. D. Enhanced evanescent wave sensors based on sol-gel-derived porous glass coatings. *Sensors and Actuators B: Chemical*, 1993. 11(1-3): 29-34.
244. Chomat, M., Berkova, D., Matejec, V., Kasik, I., Kuncova, G., & Hayer, M. Optical detection of toluene in water using an IGI optical fiber with a short sensing region. *Sensors and Actuators B: Chemical*. 2002. 87(2): 258-267.
245. Rajan, G. (Ed.). (2017). *Optical fiber sensors: advanced techniques and applications*. CRC press.
246. Haus, H. A., Fujimoto, J. G., & Ippen, E. P. Structures for additive pulse mode locking. *JOSA B*. 1991.8(10): 2068-2076.
247. Feng, X., Tam, H. Y., & Wai, P. K. A. Stable and uniform multiwavelength erbium-doped fiber laser using nonlinear polarization rotation. *Optics express*. 2006. 14(18): 8205-8210.
248. Denker, B., & Shklovsky, E. (Eds.). (2013). *Handbook of solid-state lasers: materials, systems and applications*. Elsevier.
249. Wang, M., Zhang, F., Wang, Z., & Xu, X. Liquid-phase exfoliated silicon nanosheets: saturable absorber for solid-state lasers. *Materials*. 2019. 12(2): 201.
250. Tian, W., Yu, W., Shi, J., & Wang, Y. The property, preparation and application of topological insulators: a review. *Materials*. 2017. 10(7): 814.
251. Voshell, A., Terrones, M., & Rana, M. Review of optical properties of two-dimensional transition metal dichalcogenides. In Wide Bandgap Power and Energy Devices and Applications III. *International Society for Optics and Photonics*. 2018, September. 10754: 107540L.
252. Liu, X., Gao, Q., Zheng, Y., Mao, D., & Zhao, J. Recent progress of pulsed fiber lasers based on transition-metal dichalcogenides and black phosphorus saturable absorbers. *Nanophotonics*. 2020. 9(8): 2215-2231.
253. Ahmad, H., Aidit, S. N., Ooi, S. I., & Tiu, Z. C. Tunable passively Q-switched erbium-doped fiber laser with Chitosan/MoS₂ saturable absorber. *Optics & Laser Technology*. 2018. 103: 199-205.
254. Zhao, R., He, J., Su, X., Wang, Y., Sun, X., Nie, H., ... & Yang, K. Tunable high-power Q-switched fiber laser based on BP-PVA saturable absorber. *IEEE Journal of Selected Topics in Quantum Electronics*. 2018. 24(3): 1-5.

255. Fan, D., Mou, C., Bai, X., Wang, S., Chen, N., & Zeng, X. Passively Q-switched erbium-doped fiber laser using evanescent field interaction with gold-nanosphere based saturable absorber. *Optics express*. 2014. 22(15): 18537-18542.
256. Sun, L., Lin, Z., Peng, J., Weng, J., Huang, Y., & Luo, Z. Preparation of few-layer bismuth selenide by liquid-phase-exfoliation and its optical absorption properties. *Scientific reports*. 2014. 4(1): 1-9.
257. Ahmad, H., Reduan, S. A., Ali, Z. A., Ismail, M. A., Ruslan, N. E., Lee, C. S. J., ... & Harun, S. W. C-band Q-switched fiber laser using titanium dioxide (TiO_2) as saturable absorber. *IEEE Photonics Journal*. 2015. 8(1): 1-7.
258. Wang, J., Li, S., Xing, Y., Chen, L., Wei, Z., & Wang, Y. A high-energy passively Q-switched Yb-doped fiber laser based on WS_2 and Bi_2Te_3 saturable absorbers. *Journal of Optics*. 2017. 19(9): 095506.
259. Sadeq, S. A., Al-Hayali, S. K., Harun, S. W., & Al-Janabi, A. Copper oxide nanomaterial saturable absorber as a new passive Q-switcher in erbium-doped fiber laser ring cavity configuration. *Results in Physics*. 2018. 10: 264-269.
260. Ahmad, H., & Reduan, S. A. S+/S band passively Q-switched thulium-fluoride fiber laser based on using gallium selenide saturable absorber. *Optics & Laser Technology*. 2018. 107: 116-121.
261. Baharom, M. F., Rahman, M. F. A., Latiff, A. A., Wang, P., Arof, H., & Harun, S. W. Lutetium oxide film as a passive saturable absorber for generating Q-switched fiber laser at 1570 nm wavelength. *Optical Fiber Technology*. 2019. 50: 82-86.
262. Li, S., Yin, Y., Ouyang, Q., Ran, G., Chen, Y., Lewis, E., ... & Wang, P. (2019). Nanosecond passively Q-switched fibre laser using a NiS_2 based saturable absorber. *Optics express*. 2019. 27(14): 19843-19851.
263. Wang, N., Lu, B. L., Qi, X. Y., Jiao, Y., Wen, Z. R., Chen, H. W., & Bai, J. T. Passively Q-switched ytterbium-doped fiber laser with $ReSe_2$ saturable absorber. *Optics & Laser Technology*. 2019. 116: 300-304.
264. Kasim, N., Latiff, A. A., Rusdi, M. F. M., Hisham, M. B., Harun, S. W., & Razak, N. F. Short-pulsed Q-switched Thulium doped fiber laser with graphene oxide as a saturable absorber. *Optik*. 2018. 168: 462-466.

265. Zhang, K., Wen, Z., Lu, B., Chen, H., Zhang, C., Qi, X., & Bai, J. (2020). Passively Q-switched pulsed fiber laser with higher-order modes. *Infrared Physics & Technology*. 2020. 105: 103163.
266. Ahmad, H., Aidit, S. N., & Yusoff, N. Bismuth oxide nanoflakes for passive Q-switching in a C-band erbium doped fiber laser. *Infrared Physics & Technology*. 2018. 95: 19-26.
267. Lee, J., Lee, J., Koo, J., & Lee, J. H. Graphite saturable absorber based on the pencil-sketching method for Q-switching of an erbium fiber laser. *Applied optics*. 2016. 55(2): 303-309.
268. Liu, M., Ouyang, Y., Hou, H., Liu, W., & Wei, Z. Q-switched fiber laser operating at 1.5 μm based on WTe₂. *Chinese Optics Letters*. 2019. 17(2): 020006.
269. Muhammad, A. R., Zakaria, R., Ahmad, M. T., Wang, P., & Harun, S. W. Pure gold saturable absorber for generating Q-switching pulses at 2- μm in Thulium-doped fiber laser cavity. *Optical Fiber Technology*. 2019. 50: 23-30.
270. Lee, J., Kwon, S., & Lee, J. H. Ti₂AlC-based saturable absorber for passive Q-switching of a fiber laser. *Optical Materials Express*. 2019. 9(5): 2057-2066.
271. Cai, Y., He, Y., Zhang, X., Jiang, R., Su, C., & Li, Y. Submicrosecond Q-switching Er-doped all-fiber ring laser based on black phosphorus. *Advances in Condensed Matter Physics*. 2017.
272. Liu, G., Lyu, Y., Li, Z., Wu, T., Yuan, J., Yue, X., ... & Fu, S. Q-switched erbium-doped fiber laser based on silicon nanosheets as saturable absorber. *Optik*, 2020. 202: 163692.
273. Khaleel, W. A., Sadeq, S. A., Alani, I. A. M., & Ahmed, M. H. M. Magnesium oxide (MgO) thin film as saturable absorber for passively mode locked erbium-doped fiber laser. *Optics & Laser Technology*. 2019. 115: 331-336.
274. Steinberg, D., Zapata, J. D., de Souza, E. A. T., & Saito, L. A. (2018). Mechanically exfoliated graphite onto D-shaped optical fiber for femtosecond mode-locked erbium-doped fiber laser. *Journal of Lightwave Technology*. 2018. 36(10): 1868-1874.
275. Ahmad, H., Soltani, S., Thambiratnam, K., Yasin, M., & Tiu, Z. C. Mode-locking in Er-doped fiber laser with reduced graphene oxide on a side-polished fiber as saturable absorber. *Optical Fiber Technology*. 2019. 50: 177-182.

276. Li, X., Xu, W., Hui, Z., Guo, P., Liu, J., & Zhang, Y. Cu₂S nanosheets for ultrashort pulse generation in near-infrared regions. *Nanoscale*. 2019. 11: 6045-6051.
277. Li, L., Wang, Y., Wang, X., Lv, R., Liu, S., Chen, Z., & Wang, J. Generation of dark solitons in Er-doped fiber laser based on ferroferric-oxide nanoparticles. *Optics & Laser Technology*. 2018. 103: 354-358.
278. Wu, Q., Jin, X., Chen, S., Jiang, X., Hu, Y., Jiang, Q., ... & Zhang, H. MXene-based saturable absorber for femtosecond mode-locked fiber lasers. *Optics express*. 2019. 27(7): 10159-10170.
279. Salam, S., Al-Masoodi, A. H. H., Yasin, M., & Harun, S. W. Soliton mode-locked Er-doped fiber laser by using Alq₃ saturable absorber. *Optics & Laser Technology*. 2020. 123: 105893.
280. Liu, S., Lv, R., Wang, Y., Wang, J., Wang, Y., & Wang, H. Passively Mode-Locked Fiber Laser with WS₂/SiO₂ Saturable Absorber Fabricated by Sol-Gel Technique. *ACS Applied Materials & Interfaces*. 2020.
281. Nady, A., Baharom, M. F., Latiff, A. A., & Harun, S. W. Mode-locked erbium-doped fiber laser using vanadium oxide as saturable absorber. *Chinese Physics Letters*. 2018. 35(4): 044204.
282. Ismail, E. I., Ahmad, F., Shafie, S., Yahaya, H., Latif, A. A., & Muhammad, F. D. Copper nanowires based mode-locker for soliton nanosecond pulse generation in erbium-doped fiber laser. *Results in Physics*. 2020. 103228.
283. Ahmad, H., Samion, M. Z., Kamely, A. A., & Ismail, M. F. (2019). Mode-locked thulium doped fiber laser with zinc oxide saturable absorber for 2-μm operation. *Infrared Physics & Technology*. 2019. 97, 142-148.
284. Thirumoorthi, M., & Thomas Joseph Prakash, J. Structure, optical and electrical properties of indium tin oxide ultrathin films prepared by jet nebulizer spray pyrolysis technique. *Journal of Asian Ceramic Societies*. 2016. 4(1): 124-132.
285. Neri, G., Bonavita, A., Micali, G., Rizzo, G., Callone, E., & Carturan, G. Resistive CO gas sensors based on In₂O₃ and InSnO_x nanopowders synthesized via starch-aided sol-gel process for automotive applications. *Sensors and Actuators B: Chemical*. 2008. 132(1): 224-233.
286. Manifacier, J. C. Thin metallic oxides as transparent conductors. *Thin Solid Films*. 1982. 90(3): 297-308.

287. Lewis, B. G., & Paine, D. C. Applications and processing of transparent conducting oxides. *MRS bulletin*. 2000. 25(8): 22-27.
288. Eason, R. (Ed.). (2007). *Pulsed laser deposition of thin films: applications-led growth of functional materials*. John Wiley & Sons.
289. Afre, R. A., Sharma, N., Sharon, M., & Sharon, M. Transparent conducting oxide films for various applications: A review. *Reviews on Advanced Materials Science*. 2018. 53(1): 79-89.
290. Kasap, S., & Capper, P. (Eds.). (2017). *Springer handbook of electronic and photonic materials*. Springer.
291. Hsu, H. P., Lin, D. Y., Lu, C. Y., Ko, T. S., & Chen, H. Z. Effect of lithium doping on microstructural and optical properties of ZnO nanocrystalline films prepared by the sol-gel method. *Crystals*. 2018. 8(5): 228.
292. Basak, A., Hati, A., Mondal, A., Singh, U. P., & Taheruddin, S. K. Effect of substrate on the structural, optical and electrical properties of SnS thin films grown by thermal evaporation method. *Thin Solid Films*. 2018. 645: 97-101.
293. Li, X., Colombo, L., & Ruoff, R. S. Synthesis of graphene films on copper foils by chemical vapor deposition. *Advanced Materials*. 2016. 28(29): 6247-6252.
294. Anand, V., Sakthivelu, A., Kumar, K. D. A., Valanarasu, S., Ganesh, V., Shkir, M., ... & Algarni, H. Rare earth Eu³⁺ co-doped AZO thin films prepared by nebulizer spray pyrolysis technique for optoelectronics. *Journal of Sol-Gel Science and Technology*. 2018. 86(2): 293-304.
295. Yong, T. K., Tan, S. S., Nee, C. H., Yap, S. S., Kee, Y. Y., Sáfrán, G., ... & Tou, T. Y. Pulsed laser deposition of indium tin oxide nanowires in argon and helium. *Materials Letters*. 2012. 66(1): 280-281.
296. Zalkepali, N. U. H. H., Awang, N. A., Yuzaile, Y. R., Zakaria, Z., Latif, A. A., Ali, A. H., & Mahmud, N. N. H. E. N. Indium tin oxide thin film based saturable absorber for Q-switching in C-band region. In *Journal of Physics: Conference Series*. 2019. 1371(1): 012018.
297. Rattenberger, J., Melischnig, A., Letofsky-Papst, I., Ganner, T., & Schrottner, H. (2016). Improvement of Metallic Thin Films for HR-SEM by Using DC Magnetron Sputter Coater.
298. Clark, B. J., Frost, T., & Russell, M. A. (Eds.). (1993). *UV Spectroscopy: Techniques, instrumentation and data handling* (Vol. 4). Springer Science & Business Media.

299. Tsai, D. C., Chang, Z. C., Kuo, B. H., Wang, Y. H., Chen, E. C., & Shieu, F. S. Thickness dependence of the structural, electrical, and optical properties of amorphous indium zinc oxide thin films. *Journal of Alloys and Compounds*. 2018. 743: 603-609.
300. Frank, G., & Köstlin, H. Electrical properties and defect model of tin-doped indium oxide layers. *Applied Physics A*. 1982. 27(4): 197-206.
301. Mir, F. A., u Rehman, S., Asokan, K., Khan, S. H., & Bhat, G. M. Optical, DC and AC electrical investigations of 4-hydroxy coumarin molecule as an organic Schottky diode. *Journal of Materials Science: Materials in Electronics*. 2014. 25(3): 1258-1263.
302. Mir, F. A., Bhat, G. M., Asokan, K., Batoo, K. M., & Banday, J. A. Crystal structure, morphological, optical and electrical investigations of Oxypeucedanin micro crystals: an isolated compound from a plant. *Journal of Materials Science: Materials in Electronics*. 2014. 25(1): 431-437.
303. Premkumar, M., & Vadivel, S. Effect of annealing temperature on structural, optical and humidity sensing properties of indium tin oxide (ITO) thin films. *Journal of Materials Science: Materials in Electronics*. 2017. 28(12): 8460-8466.
304. Dong, L., Zhu, G. S., Xu, H. R., Jiang, X. P., Zhang, X. Y., Zhao, Y. Y., ... & Yu, A. B. Preparation of indium tin oxide (ITO) thin film with (400) preferred orientation by sol-gel spin coating method. *Journal of Materials Science: Materials in Electronics*. 2019. 30(8): 8047-8054.
305. Awang, N. A., Azmi, A. N., Yuzaile, Y. R., Zalkepali, N. U. H. H., & Zakaria, Z. Mode-locking soliton generation using platinum in figure-8 configuration. *Optical Fiber Technology*. 2019. 52: 101956.
306. Ma, J., Xie, G. Q., Lv, P., Gao, W. L., Yuan, P., Qian, L. J., & Tang, D. Y. Graphene mode-locked femtosecond laser at 2 μm wavelength. *Optics letters*. 2012. 37(11): 2085-2087.
307. Rozhin, A. G., Sakakibara, Y., Namiki, S., Tokumoto, M., Kataura, H., & Achiba, Y. Sub-200-fs pulsed erbium-doped fiber laser using a carbon nanotube-polyvinylalcohol mode locker. *Applied physics letters*. 2006. 88(5):051118.
308. Ahmad, H., Faruki, M. J., Razak, M. Z. A., Jaddoa, M. F., Azzuhri, S. R., Rahman, M. T., & Ismail, M. F. A combination of tapered fibre and

- polarization controller in generating highly stable and tunable dual-wavelength C-band laser. *Journal of Modern Optics*. 2017. 64(7): 709-715.
309. Olympus Corporation (2020). Knowledge: Optical microscopes. Retrieved on April 15, 2020, from <https://www.olympusims.com/en/microscope/terms/feature10/>.
310. Lide, D. R. (Ed.). (2004). *CRC handbook of chemistry and physics* (Vol. 85). CRC press.
311. Bolshtyansky, M. Spectral hole burning in erbium-doped fiber amplifiers. *Journal of lightwave technology*. 2003. 21(4): 1032-1038.
312. Liu, X., & Cui, Y. Flexible pulse-controlled fiber laser. *Scientific reports*. 2015. 5(1):1-5.
313. Monga, K. J. J., Meyer, J., & Manuel, R. M. Implementation of active Q-switching based on a modulated fiber Fabry-Perot filter in linear cavity erbium doped fiber laser. In *2017 IEEE AFRICON*. 2017, September. 620-624.
314. Han, Y., Guo, Y., Gao, B., Ma, C., Zhang, R., & Zhang, H. Generation, optimization, and application of ultrashort femtosecond pulse in mode-locked fiber lasers. *Progress in Quantum Electronics*. 2020: 100264.
315. Erdogan, T. Fiber grating spectra. *Journal of Lightwave Technology*. 1997. 15(8): 1277-1294.
316. Lin, C. Y., Chern, G. W., & Wang, L. A. Periodical corrugated structure for forming sampled fiber Bragg grating and long-period fiber grating with tunable coupling strength. *Journal of Lightwave Technology*. 2001. 19(8): 1212-1220.
317. Zhang, C., Liu, L., Liu, Z., Zheng, S., Zhao, R., & Jian, S. Tunable multi-wavelength fiber laser based on a polarization-maintaining erbium-doped fiber and a polarization controller. *Optics Communications*. 2011. 284(10-11): 2550-2553.
318. Li, L., Lv, R., Wang, J., Chen, Z., Wang, H., Liu, S., ... & Wang, Y. Optical nonlinearity of ZrS₂ and applications in fiber laser. *Nanomaterials*. 2019. 9(3): 315.
319. Derickson, D., Hentschel, C., & Vobis, J. (1998). *Fiber optic test and measurement* (Vol. 8). New Jersey: Prentice Hall PTR.
320. Lin, K. H., Kang, J. J., Wu, H. H., Lee, C. K., & Lin, G. R. Manipulation of operation states by polarization control in an erbium-doped fiber laser with a hybrid saturable absorber. *Optics express*. 2019. 17(6): 4806-4814.

321. Ahmad, H., Salim, M. A. M., Soltanian, M. R. K., Azzuhri, S. R., & Harun, S. W. Passively dual-wavelength Q-switched ytterbium doped fiber laser using Selenium Bismuth as saturable absorber. *Journal of Modern Optics*. 2015. 62(19): 1550-1554.
322. Ahmad, H., Zainudin, F. M., Azmi, A. N., Thambiratnam, K., Ismail, M. F., Aminah, N. S., & Zulkifli, M. Z. Compact L-band switchable dual wavelength SOA based on linear cavity fiber laser. *Optik*. 2019. 182: 37-41.
323. Zhang, C. F., Sun, J., Zheng, S. W., & Jian, S. S. A simple mechanism to suppress the mode competition for stable and tunable dual-wavelength erbium-doped fiber lasers. In *Advanced Materials Research*. 2012. 571:496-499.
324. Yamashita, S., & Hotate, K. Multiwavelength erbium-doped fibre laser using intracavity etalon and cooled by liquid nitrogen. *Electronics Letters*. 1996. 32(14): 1298-1299.
325. Park, N., & Wysocki, P. F. 24-line multiwavelength operation of erbium-doped fiber-ring laser. *IEEE Photonics Technology Letters*. 1996. 8(11): 1459-1461.
326. Graydon, O., Loh, W. H., Laming, R. I., & Dong, L. Triple-frequency operation of an Er-doped twincore fiber loop laser. *IEEE Photonics Technology Letters*. 1996. 8(1): 63-65.
327. Shawki, H., Kotb, H., & Khalil, D. Modeling and characterization of a dual-wavelength SOA-based single longitudinal mode random fiber laser with tunable separation. *OSA Continuum*. 2019. 2(2): 358-369.
328. Timmer, B., Olthuis, W., & Van Den Berg, A. Ammonia sensors and their applications—a review. *Sensors and Actuators B: Chemical*. 2005. 107(2): 666-677.
329. Narducci, D. Biosensing at the nanoscale: There's plenty of room inside. *Science of Advanced Materials*. 2011. 3(3): 426-435.
330. Ho, G. W. Gas sensor with nanostructured oxide semiconductor materials. *Science of Advanced Materials*. 2011. 3(2): 150-168.
331. Raj, V. B., Nimal, A. T., Parmar, Y., Sharma, M. U., Sreenivas, K., & Gupta, V. Cross-sensitivity and selectivity studies on ZnO surface acoustic wave ammonia sensor. *Sensors and Actuators B: Chemical*. 2010. 147(2): 517-524.
332. Malins, C., Doyle, A., MacCraith, B. D., Kvasnik, F., Landl, M., Šimon, P., ... & Babusik, I. Personal ammonia sensor for industrial environments. *Journal of Environmental Monitoring*. 1999. 1(5): 417-422.

333. Cao, W., & Duan, Y. Optical fiber-based evanescent ammonia sensor. *Sensors and Actuators B: Chemical*. 2005. 110(2): 252-259.
334. Shankar, S. S., & Deka, S. Metal nanocrystals and their applications in biomedical systems. *Science of Advanced Materials*. 2011. 3(2): 169-195.
335. Xu, X., Fang, X., Zeng, H., Zhai, T., Bando, Y., & Golberg, D. One-dimensional nanostructures in porous anodic alumina membranes. *Science of Advanced Materials*. 2010. 2(3): 273-294.
336. Chou, T. C., Chang, C. H., Lee, C., & Liu, W. C. (2018). Ammonia sensing characteristics of a tungsten trioxide thin-film-based sensor. *IEEE Transactions on Electron Devices*, 66(1), 696-701.
337. Kathwate, L. H., Umadevi, G., Kulal, P. M., Nagaraju, P., Dubal, D. P., Nanjundan, A. K., & Mote, V. D. (2020). Ammonia gas sensing properties of Al doped ZnO thin films. *Sensors and Actuators A: Physical*, 313, 112193.
338. Zhu, Y., Yu, L., Wu, D., Lv, W., & Wang, L. (2021). A high-sensitivity graphene ammonia sensor via aerosol jet printing. *Sensors and Actuators A: Physical*, 318, 112434.
339. Fu, H., Wang, Q., Ding, J., Zhu, Y., Zhang, M., Yang, C., & Wang, S. (2020). Fe₂O₃ nanotube coating micro-fiber interferometer for ammonia detection. *Sensors and Actuators B: Chemical*, 303, 127186.
340. Pisco, M., Consales, M., Viter, R., Smyntyna, V., Campopiano, S., Giordano, M., ... & Cutolo, A. Novel SnO₂ based optical sensor for detectin of low ammonia concentration in water at room temperatures. *Semiconductor Physics Quantum Electronics & Optoelectronics*. 2005. 8(1):95-99.
341. Iga, M., Seki, A., & Watanabe, K. Gold thickness dependence of SPR-based hetero-core structured optical fiber sensor. *Sensors and Actuators B: Chemical*, 2005. 106(1): 363-368.
342. Dubas, S. T., & Pimpan, V. Green synthesis of silver nanoparticles for ammonia sensing. *Talanta*, 2008. 76(1): 29-33.
343. Pisco, M., Consales, M., Campopiano, S., Viter, R., Smyntyna, V., Giordano, M., & Cusano, A. A novel optochemical sensor based on SnO₂ sensitive thin film for ppm ammonia detection in liquid environment. *Journal of lightwave technology*. 2006. 24(12): 5000-5007.