Micro-530 / Spring 2025 semester / Review paper selected by groups

Blue text: own summary

Purple text: AI summary

Group	Members	Topic	Review paper
A	victor.cartier-negadi@epfl.ch daniel.elmaleh@epfl.ch paul.krassiakov@epfl.ch arthur.lettermann@epfl.ch maureen.spick@epfl.ch	Nano photonics	Huang, C.-Y.; Hong, K.-B.; Huang, Z.-T.; Hsieh, W.-H.; Huang, W.-H.; Lu, T.-C. Challenges and Advancement of Blue III-Nitride Vertical-Cavity Surface-Emitting Lasers. Micromachines 2021, 12, 676. https://doi.org/10.3390/mi12060676 *Blue VCSELs offer compact, efficient photonic devices. Since NCTU demonstrated III-nitride blue-VCSELs in 2008, academia and industry, including EPFL and Sony, have improved performance using GaN-based materials, DBR mirrors, and quantum dots. Advancements include higher power, better cavities, and mirrors. Future work targets arrays, broader wavelengths, and lower thresholds.* *Gemini Summary: This review details progress in blue/green III-nitride vertical-cavity surface-emitting lasers (VCSELs), crucial for applications like optical storage and displays, where shorter wavelengths offer higher density and resolution. Challenges include polarization effects and fabrication complexities. Key contributors include NCTU, Nichia, Sony, Panasonic, and the University of California, Santa Barbara.*
B	aude.chigard@epfl.ch daniel.dasilva@epfl.ch simon.fink@epfl.ch chloe.klose@epfl.ch clemence.rey@epfl.ch	Nano fabrication	S. Gu, B. Chen, X. Xu, F. Han, S.-C. Chen, 3D Nanofabrication via Directed Material Assembly: Mechanism, Method, and Future. Adv. Mater. 2025, 37, 2312915. https://doi.org/10.1002/adma.202312915 *This article explores different 3D nanofabrication techniques, covering chemical, physical and hybrid methods. It focuses on resolution, material compatibility and scalability. We selected it for its comparative analysis of the different nanofabrication methods applied in nanorobotics, sensors, etc., all significant topics in the development of nanotechnology.* *The paper reviews 3D nanofabrication through directed material assembly, highlighting emerging techniques like self-assembly, additive manufacturing, and laser-based structuring. It discusses precision control, scalability, and functional applications in electronics, biomedicine, and optics. The study emphasizes challenges in reproducibility and integration, advocating interdisciplinary approaches for advancing nanoscale engineering.*
C	benjamin.deprez@epfl.ch fanny.ghez@epfl.ch alexandre.kiss@epfl.ch pierre.parvex@epfl.ch samira.tscherrig@epfl.ch	Carbon nanotubes	Review of Carbon Nanotube Research and Development: Materials and Emerging Applications, Kevin J. Hughes, Kavita A. Iyer, Robert E. Bird, Julian Ivanov, Saswata Banerjee, Gilles Georges, and Qiongqiong Angela Zhou ACS Applied Nano Materials 2024 7 (16), 18695-18713 https://pubs.acs.org/doi/10.1021/acsanm.4c02721

			This paper maps 20 years of CNT research, and highlights rapid growth in energy storage, sensors, and MXene/CNT composite, with strong patent activity reflecting increasing industrial interest, driven by the expansion in academic research and innovation. The emergence of CNTs holds great promise to positively impact society across multiple fields. *Carbon nanotubes (CNTs) offer groundbreaking potential in electronics, energy storage, and medicine. Their exceptional properties drive academic research and industrial applications. Future advancements in scalable production and integration will revolutionize technology, benefiting society through sustainable solutions, enhanced performance, and novel applications across industries, solidifying CNTs as a key nanomaterial.*
D	maxime.baube@epfl.ch luciano.calcoen@epfl.ch tristan.fonquernetorres@epfl.ch maxime.nourry@epfl.ch nicolas.robson@epfl.ch	Nano photonics	González-Tudela, A., Reiserer, A., García-Ripoll, J.J. et al. Light–matter interactions in quantum nanophotonic devices. Nat Rev Phys 6, 166–179 (2024). https://doi.org/10.1038/s42254-023-00681-1 *This publication presents advancements and interests in label-free nanophotonic biosensors from a mutidisciplinary perspective, as well as an overview of photonic-based biosensor field.* *This article was chosen from the team's interest in biosensing, optics and quantum effects. Furthermore, it presents multiple tools and techniques of interest in microengineering.* *Nanophotonic biosensors utilize subwavelength structures to enhance light–matter interactions, enabling label-free detection with high sensitivity. Advancements in integrating nanostructures with microfluidics and data analysis tools have improved their performance. Challenges remain in reducing costs and effectively handling complex biological samples.*
E	feihong.chu@epfl.ch janosh.huyse@epfl.ch nzian.koffi@epfl.ch nethan.kuruppu@epfl.ch daria.yakovchuk@epfl.ch	Nano medicine	Sindhwani S, Chan WCW, Nanotechnology for modern medicine: next step towards clinical translation (Review). J Intern Med 2021; 290: 486–498 https://doi.org/10.1111/joim.13254 *Nanomedicine is the use of nanoparticules for medical applications, including colorimetric imaging tests, imaging, drug delivery (historically against cancer, today towards other diseases and gene editing). Engineers-clinician collaboration, and a better understanding of nano-bio interactions is expected to enhance translation as only 0.7 % of particles reach the tumor site.* *Nanomedicine uses materials 1-100nm in size with unique properties for healthcare applications. Despite progress in cancer treatments, vaccines, and diagnostics, delivery efficiency remains challenging (only 0.7% reach tumors). Future advances require better understanding of nano-bio interactions and stronger collaborations between engineers and clinicians.*
G	clement.chalut@epfl.ch mathieu.dubois@epfl.ch romain.dufour@epfl.ch vincent.ellenrieder@epfl.ch chih-ying.huang@epfl.ch	Quantum dots	F. Pelayo García de Arquer et al. Semiconductor quantum dots: Technological progress and future challenges.Science 373 (2021). https://www.science.org/doi/10.1126/science.aaz8541

			Advances in photovoltaics, sensors, displays, and quantum devices are fuelled by the tunable electrical and optical characteristics of semiconductor quantum dots. The paper examines how these nanoscale developments are transforming technology and paving the way for future innovations, emphasizing progress in synthesis, integration, and sustainability. *Semiconductor quantum dots drive advances in photovoltaics, displays, sensing, and quantum tech via tunable properties. Both AI and our findings emphasize breakthroughs in synthesis, integration, and sustainability while noting challenges like toxicity and scalability.* *Prompt used: "summarize key take away messages from the review paper. 50 words max text."*
I	cortelazzo.giulia@epfl.ch alexandre.dao@epfl.ch mengozzi.federico@epfl.ch julian.ruizrodriguez@epfl.ch timofei.tunekov@epfl.ch	Nano mechanics	Magazzù, A.; Marcuello, C. Investigation of Soft Matter Nanomechanics by Atomic Force Microscopy and Optical Tweezers: A Comprehensive Review. Nanomaterials 2023, 13, 963. https://doi.org/10.3390/nano13060963 *The review compares nanomechanical characterization of softmatter (hydrogels, dendrimers, blends, foams, liquid crystals) using AFM and OT versus traditional methods. It details approaches to measure Young's modulus, hardness, and viscoelasticity at the molecular level. AFM and OT excel at detecting singularities and transient phenomena, impossible to track with traditional techniques.* *AFM and optical tweezers enable precise nanomechanical analysis of soft matter (hydrogels, cells), crucial for medical, environmental, and industrial uses. Trends integrate imaging/microfluidics for dynamic insights. Future progress requires computational models and cross-sector partnerships to advance smart materials and targeted therapies. Key players: academia/industry.*
J	nina.bodenstab@epfl.ch kilian.pouderoux@epfl.ch cyrill.reding@epfl.ch lucas.shang@epfl.ch antoine.violet@epfl.ch	Nano medicine	Xiang, H., Zhao, L., Yu, L. et al. Self-assembled organic nanomedicine enables ultrastable photo-to-heat converting theranostics in the second near-infrared biowindow. Nat Commun 12, 218 (2021). https://doi.org/10.1038/s41467-020-20566-6 *This paper explores the utilization of novel nanomaterials for medical purposes be-it as a diagnostic or as a therapeutic tool, such as drug delivery and improved imaging. Here, nanomaterials such as natural products, carbon dots, liposomes are explored. The paper demonstrates the potential application in Cancer and neurodegenerative disease treatment.* *This review explores nanomedicine's role in targeted drug delivery using advanced nanomaterials like dendrimers, liposomes, and carbon dots. Applications include cancer, Parkinson's, and Alzheimer's treatment. It emphasizes green synthesis, clinical translation hurdles, and the importance of multidisciplinary innovation and infrastructure to advance personalized, safe, and effective therapeutic solutions.*
K	arno.douady@epfl.ch ameer.elkhayat@epfl.ch mario.sancheznajera@epfl.ch johan.telley@epfl.ch	Nano electronics	Zhu, S., Ni, J. & Li, Y. Carbon nanotube-based electrodes for flexible supercapacitors. Nano Res. 13, 1825–1841 (2020). https://doi.org/10.1007/s12274-020-2729-5

	sarah.urban@epfl.ch		*Flexible supercapacitors are vital for portable/wearable electronics. CNTs are promising electrode materials assembled into fibers, films, and aerogels for bendable, stretchable, and compressible SCs. Current research focuses on improving performance, combining CNTs with pseudocapacitive materials and developing better solid-state electrolytes with scalable production techniques that are crucial for future commercialization.* *The paper explores hydrothermal synthesis for nanostructured electrode materials in energy storage. It highlights high surface area, conductivity, charge transfer efficiency, and cycle stability as key factors. The study demonstrates enhanced capacitive behavior and stability, improving supercapacitor and battery performance for sustainable energy applications.*
L	martina.giordano@epfl.ch ivonne.koedam@epfl.ch mohamed.krichene@epfl.ch constantin.wehrbach@epfl.ch pan.zhang@epfl.ch	Quantum dots	F. Pelayo García de Arquer et al.Semiconductor quantum dots: Technological progress and future challenges.Science373,eaaz8541(2021). DOI:10.1126/science.aaz8541 *Quantum dots confine electrons in a 0D structure, with size- and doping-dependent energy levels. They offer applications in light emission, charge transport, and quantum computing but face challenges like material stability, high fabrication costs, and limited material choices.* *Quantum dots drive innovation in energy, health, and information through advanced nanotechnologies, with uses in displays, lasers, sensors, solar cells, and quantum tech. Trends focus on eco-friendly synthesis and electronics integration. Progress depends on top academic research, industrial scaling, high-quality materials, and scalable manufacturing for widespread adoption.*