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Mimicking nature in growing detectors

It is a plausible approach to tackle some of the near future technical challenges by mimicking living nature, which solved many problems during evolution. The fact that helicopters or airplanes are flying is due to the technical translation of biological solutions. Regarding imaging sensors and visual systems, nature came up with far beyond state of the art solutions, which are worth to be translated into the next generation of detection systems

In wildlife, nature developed the ultimate imaging systems carrying out a number of complex tasks which includes the reception of light on high throughput image sensors (130 Mpixel, 10GB/s on human retina), on the fly data compression (two orders of magnitude from retina to optical nerve) and subsequent data processing. The latter comprises the formation of monocular representations with the subsequent buildup of a binocular perception from a pair of two-dimensional projections. This allows the identification and categorization of visual objects, assessing distances to and between objects and their movement in real-time. Eventually large data volumes are stored incrementally and over long time in relatively small data back ends (some tenths of cm3).
These complex systems are grown and self assembled from a single seed and built up by nanometer-sized building blocks whereas neuronal activity profoundly influences the growth of axonal terminals, contributing to their final size and form. During the final phases of visual system development, adult patterns of neuronal connectivity are achieved via an activity-driven process of synaptic rearrangement.
With these characteristics in mind and in view of future challenges in imaging technology it is worth the effort to try to mimic nature's approach in growing and self-assembling detectors from nanometer-sized building blocks. Obviously it will take a long way to grow and self assemble an entire imaging system, however, with the technology available nowadays such as graphene, 3-d printing or molecular beam epitaxy (MBE), at least sensors can be grown.
Due to their tunable and direct band gap detectors grown by MBE utilizing III/V semiconductor materials are extremely interesting for the next generation of multi wavelength imaging systems operating in regimes from THz to hard x-rays with sub nano second time resolution. The latter is due to nanometer sized quantum structures, which allows to host two-dimensional electronic gases possessing extreme high charge carrier mobility and enables charge amplification on the sensor level.
With regard to ATTRACT the idea would to grow small size (max 2 ") pixilated sensors (pixel size ~ 50 µm) using InGaAs and InAAs comprising single or multiple quantum wells for charge amplification. A thorough sensor characterization includes the assessment of efficiency for different wavelengths including THz radiation, and the assessment of spatial and time resolution with ultra FEL soft x-ray pulses utilizing standard readout electronics. To go further 3D bioprinting techniques using will be fathomed to assemble high complexity nerve tissue for the sensor read out. Polymer materials will serve as scaffold for growing nerve tissues. The final functionality will be achieved by integrating graphene as the electrical conductor.

Summary

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