Visual prosthesis based on Silicon PhotoMultipliers: the SPEye project

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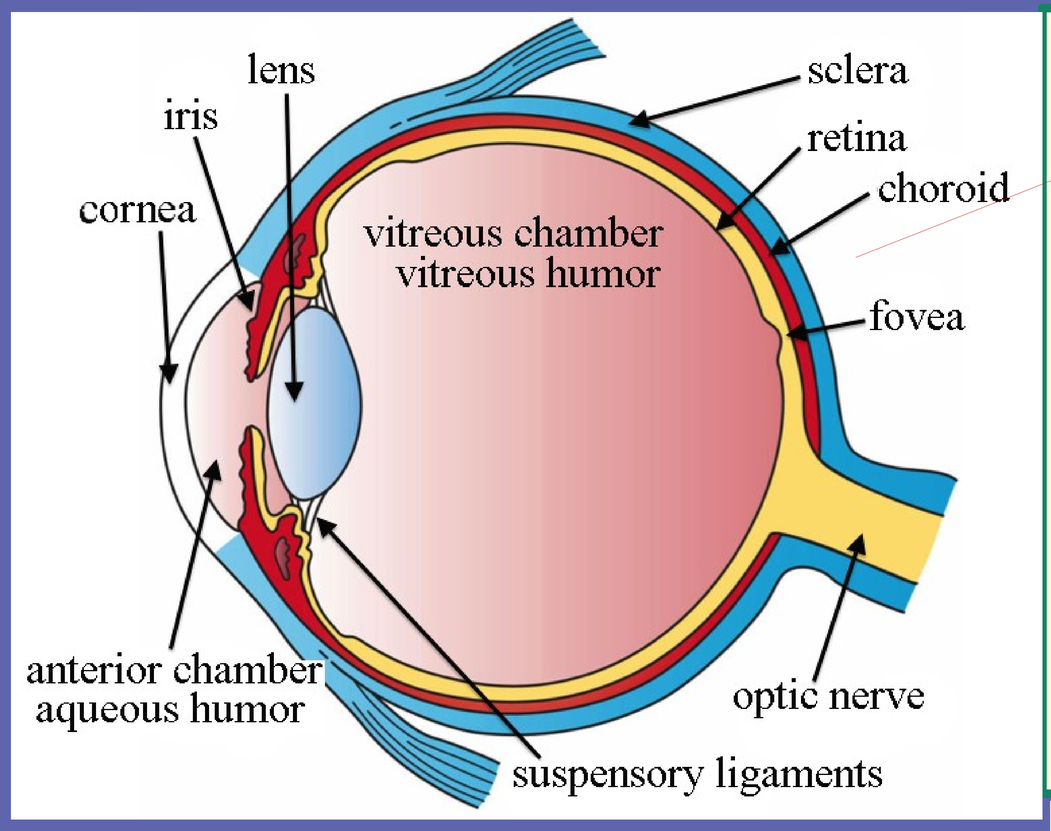
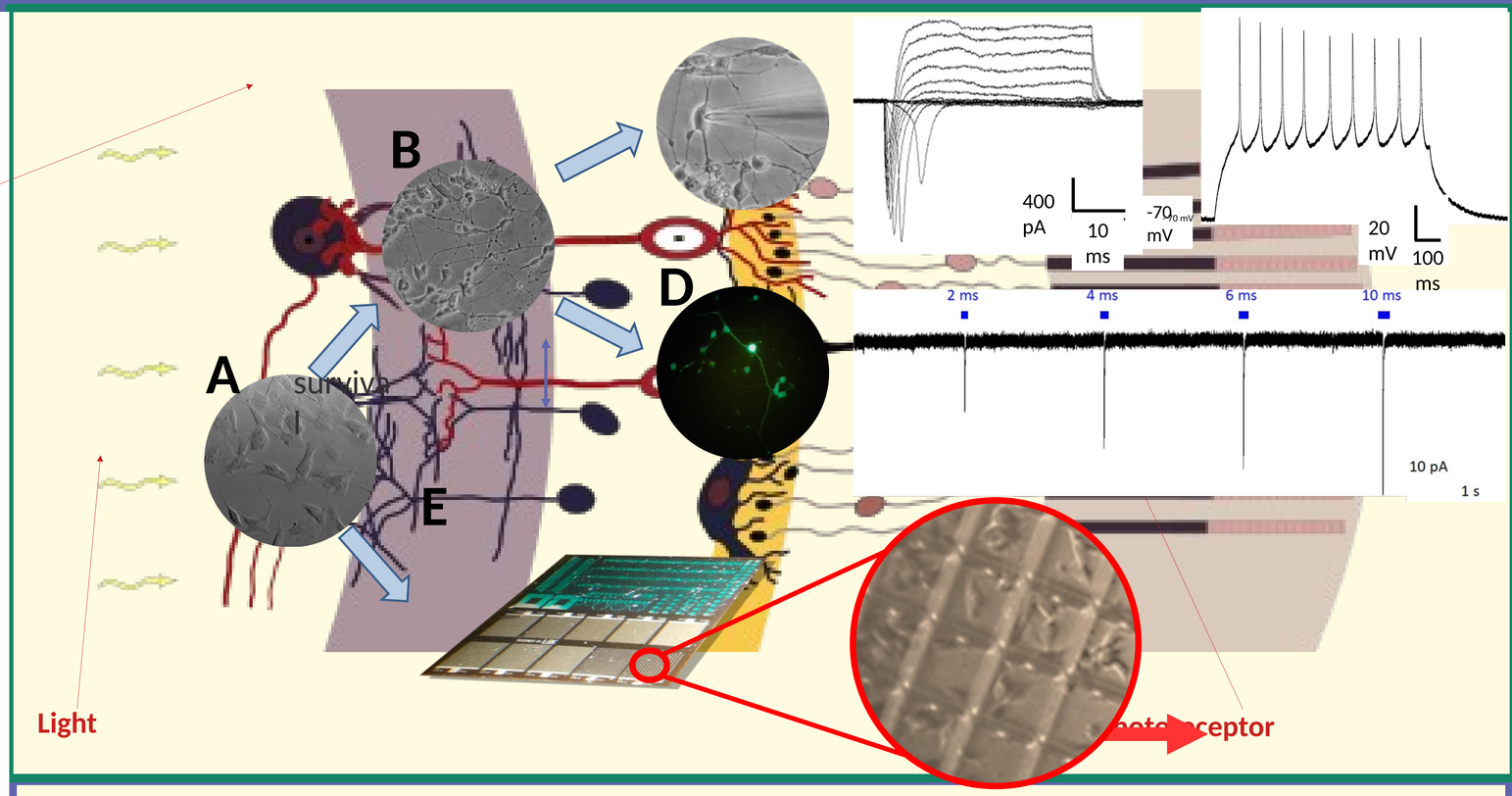
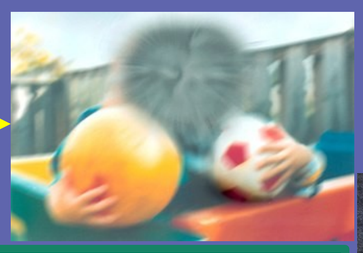
Abstract: Several retinal degenerative diseases like age-related macular degeneration (AMD) and retinitis pigmentosa (RP) cause total or partial blindness to about 1 over 4000 people in the world for a total of ~1.5 milion. Those diseases cannot be cured, the only possible improvement of life quality for the people affected is a visual prosthesis compensating the retinal damage. Such devices have been developed with interesting but limited results. We suggest an improved version based on subretinal implantation of SiPM arrays which should be able to stimulate the healthy part of the retina at low power and high visual acuity.

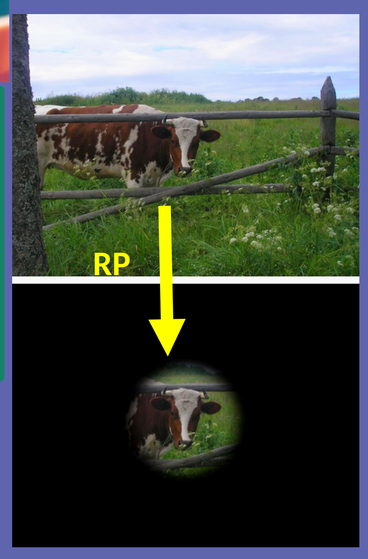




Rods, cones and nerve layers in the retina. The front (anterior) of the eye is on the left. Light (from the left) passes through several transparent nerve layers to reach rods and cones (far right). A chemical change in the rods and cones send a signal back to the nerves. The signal goes first to the bipolar and horizontal cells (yellow layer), then to the amacrine cells and ganglion cells (purple layer), then to the optic nerve fibres.



Due to retinal degeneration
different visual impairment are
Possible. With time total blindness can develop.



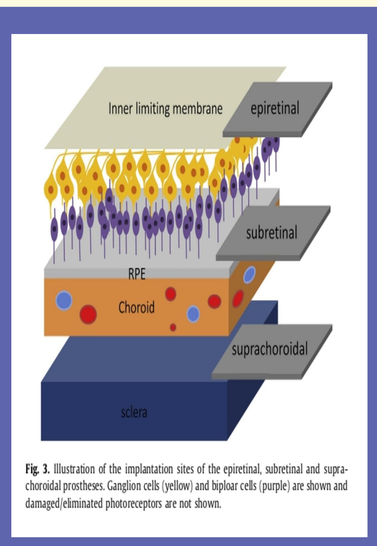
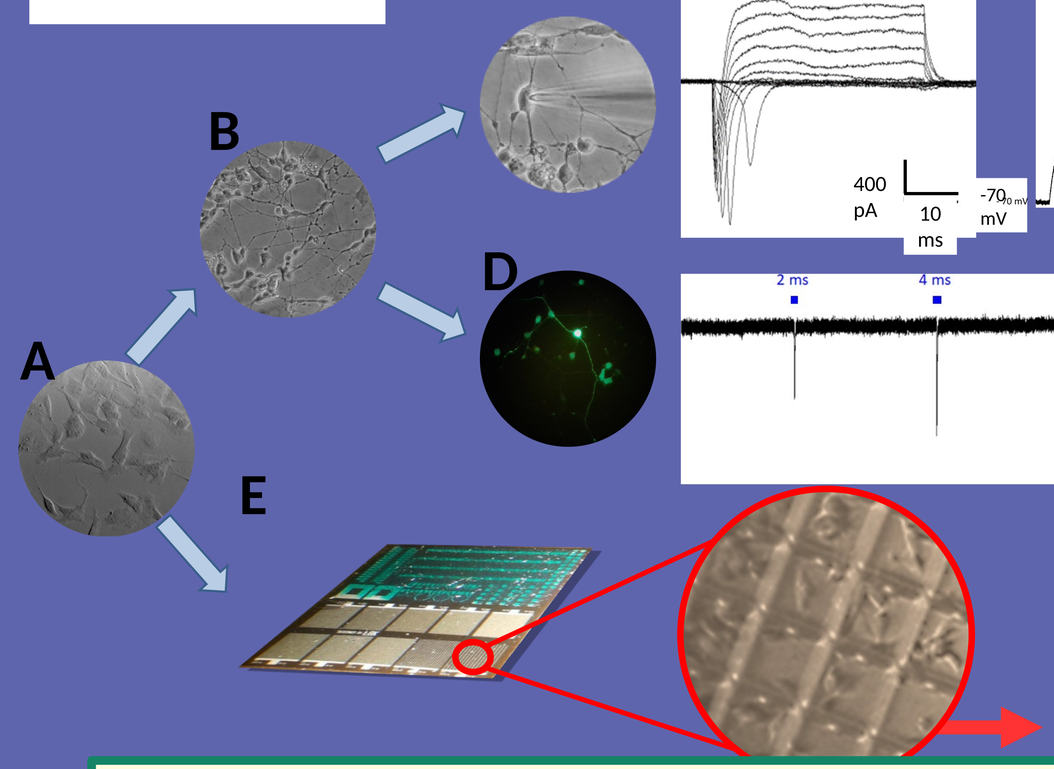


Fig. 3. Illustration of the implantation sites of the epiretinal, subretinal and supra-choroidal prostheses. Ganglion cells (yellow) and bipolar cells (purple) are shown and damaged/eliminated photoreceptors are not shown.

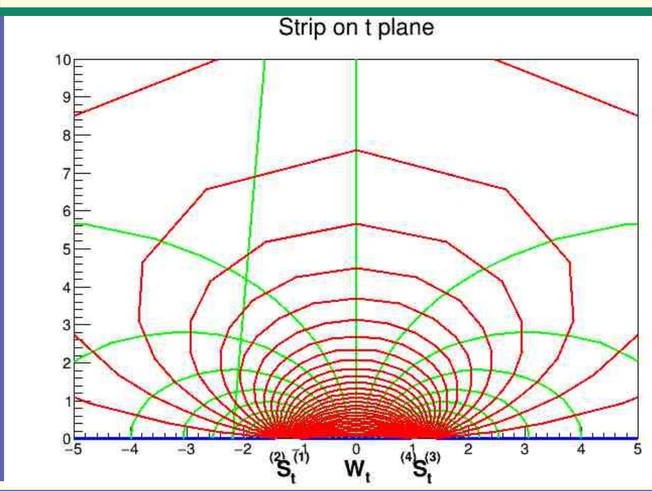
Visual prostheses can be epiretinal, subretinal or sucoroidal.
SPEye goal is to develop a subretinal prosthesis that allows to exploit the healthy retinal cells leading to the optical nerve.



Deposition of cells on SiPMs.

SiPM array as visual prosthesis

The diseases induced blindness is due to the rods and cones failure. They can be chirurgically replaced by other photodetectors inducing directly electrical signals to the innermost retina cells (horizontal, bipolar, amacrine, ganglion).
SiPMs are interesting candidates because of their large internal amplification that induces large localized electric field variation even for low intensity light and of the small size of their cells down to 10x10 μm^2.



Shape of electric field between two adiacent SiPM array cells

Items under study

- **SiPM Remote powering**
- **Living cell deposition on SiPM**
- **Characterization of response versus light power**
- **Simulation of neuron response to SiPM stimulation**
- **Mechanical matching of flat SiPM with spherical retina surface**
- **Biocompatibility and SiPM operation in physiological solution**

Web site

The project web site is https://speye.unipv.it/
Updated information are available there