Writing and reading in 3D: two-photon polymerization and microscopy

We all are familiar with the concept of pixel, the smallest controllable element of a picture represented e.g. on a computer or tablet screen. The concept of voxel, as the smallest controllable volume element, sounds instead more exotic. A voxel is a small 3-dimensional object that can be defined and moved around using lasers and lenses thanks to a non-linear optical phenomenon called two-photon absorption. We can start to dream about "3D screens" where we can read and write information in 3D.

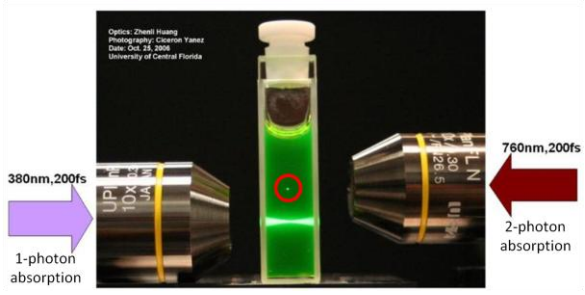

Figure (from UCF-CHEM): The one-photon (bottom of the cuvette) and two-photon absorption processes (top of the cuvette); the red circle

Two photons must be found in the same place at the same time for two-photon absorption, a process that requires the high light intensities (large photon concentrations) that can only be found at the focus position of a focused laser beam. Two-photon absorption then defines the voxel as a region of space so small as a cube whose edge is a million part of the edge of the liter-cube. We can "read" a voxel looking at the light emitted after two-photon excitation: 2-photon bioimaging allows us to see what happens inside biological tissues, spotting very small objects that can be reconstructed in 3D. To "write" in 3D we can use two-photon excitation to start polymerization within the voxel to produce very tiny and well-detailed objects.

Two-photon bio-imaging successfully exploits the light in the transparency window of biological tissues (red-infrared), and has already been demonstrated in vivo. Nanopolymerization has been used to grow photonic crystals as well as small and complex structure of interest for health application (nanosyringe, nanovalves…) that can easily be personalized. Bringing the two techniques from the advanced research labs towards extensive applications and towards the market requires the design and optimization of materials and methods and represents the main aim of **Nano2Fun**, *Nanochemistry of Molecular Materials for 2-Photon Functional Applications*, an ITN project funded by the EU commission with more than 3.5 M€ in the next four years. Innovation through research and technological transfer are the flagwords of Nano2Fun, a multidisciplinary project run by a network of 16 advanced research labs, in Universities, public and private research centers distributed in Europe, India and United States, with different expertise in molecular and supramolecular synthesis, optical spectroscopy and photophysics, theoretical modelization, and technological applications and scaling up.

Figure: the kick-off meeting of Nano2Fun took place in Parma on September 19-20, 2013

The inherently multidisciplinary character of the research that spans a full range of disciplines between chemistry and physics offers an extremely profitable environment for the education through research of young researchers both in public and private sectors, in a lively international environment at the forefront of research. 17 young researchers will be hired within Nano2Fun where they will have the possibility to learn first-hand the challenging work of the scientist at the interface between advanced basic research and technological transfer. Overall the recruited scientists will work for almost 500 months in first-class research centers, equipped with advanced instrumentations. They will experience different research environments including academic laboratories, private and public research centers in Europe, India and United states. Meeting will be scheduled twice per year to discuss the research progress and to participate to thematic schools, organized for the young scientists of Nano2Fun, but open to all interested people. These schools will be devoted not just to scientific topics, but also to develop skills about scientific managment, intellectual property protection, scientific communication, ethics etc. The aim is the education to research in all its multifacted aspects: from field work Nano2Fun students will learn the importance of team-work, the benefits of multi and inter-disciplinarity and the tight an fruitful link between basic research and applications, but they will also appreciate the richness of multicultural environments and the importance of gender balance to really succeed as the new generation of scientists, educated in Europe but ready to meet the challenge of scientific research in the global world.