

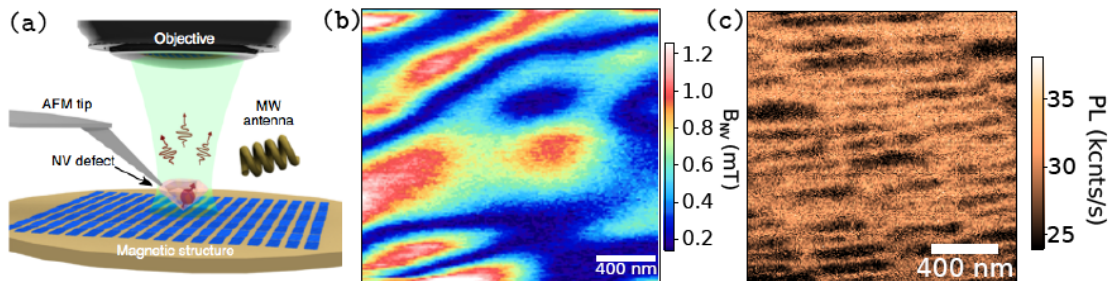
# Nanoscale imaging using nanoparticles

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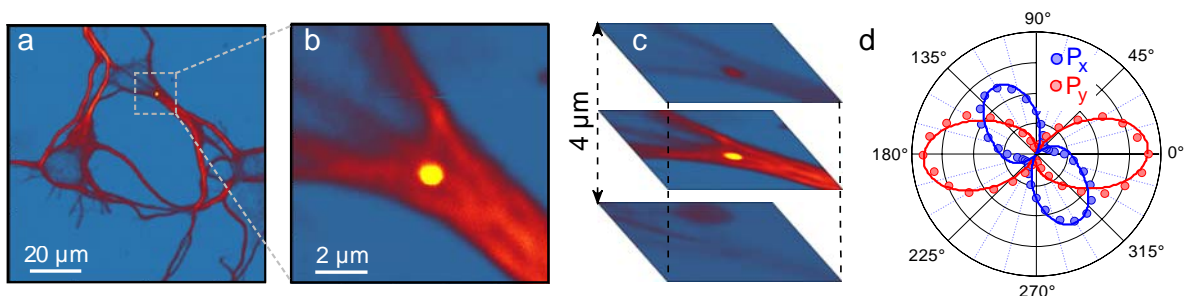
Numerous works have been devoted to the development of efficient probes for nanoscale measurements and imaging. I will describe in my talk two types of nanoscale probes, with different spectroscopic properties.

I will first report on our work on the production of nanodiamonds and their application to magnetic field mapping using the spin properties of the nitrogen-vacancy (NV) defect hosted in a diamond nanocrystal. The nanocrystal is attached to the tip of an atomic force microscope (Fig.1a). Two techniques, based either on optically detected electron spin resonance (Fig.1b) or on magnetic-field-dependent photoluminescence (Fig.1c), are demonstrated using a magnetic hard disk as a test sample. Combining nanometer scale spatial resolution, high sensitivity and room temperature operation, this NV-based scanning microscope should open up numerous perspectives in nanomagnetism and spintronics.



**Fig. 1.** Scheme of the scanning NV defect microscope used to map the magnetic field created by the bits encoded on a magnetic hard disk.

I will then describe nanoparticles with nonlinear optical response.  $\text{KTiOPO}_4$  (KTP) is a well-known material for second-harmonic generation (SHG) which can be synthesized as nanocrystals with size below 30 nm. Under femtosecond infrared optical excitation, the KTP nanoparticles exhibit non-bleaching and non-blinking SHG. Their crystalline orientation can be fully determined using the SHG high sensitivity to the polarization of the excitation field. These nanocrystals can be applied as nonlinear optical probes for nano-medicine as shown in a proof-of-principle experiment where KTP nanoparticles have been introduced into a culture medium with mouse primal neural cells. Discrete KTP nanoparticles can be imaged inside the cell body and the neurites without any visible impact on the short term development of the cells (Fig. 2).



**Fig. 2.** SHG from an individual KTP nanocrystal. (a), (b) and (c) Images of a neural cell marked with TRITC simultaneously showing the SHG from a discrete KTP nanocrystal (bright spot). (d) Polarization response diagram allowing us to infer the in-situ orientation of the nanocrystal.

## Jean-François Roch

The research career of Jean-François Roch began in 1987, with his PhD on Quantum Non-Destructive measures done at the Institut d'Optique under the direction of P. Grangier. He was then recruited in 1992 by the CNRS as assistant researcher in the Quantum Optics group at the Institut d'Optique. The experiment that he made in 1996, using trapped cold atoms as nonlinear medium, is still today the most efficient QND measure. He then proposed and set up a "quasi-QND" experiment using only semiconductor as emitters and receivers. From 1996 to 1998, he worked in the team of S. Laroche, J.-M. Raimond, V.



Lefevre-Seguin and J. Hare in the Kastler-Brossel laboratory. There, he was able to observe the intrinsic Kerr bistability of silica microsphere resonators immersed in superfluid helium. Since 1998, he is a professor at the ENS Cachan and the head of the "Quantum Nanophotonics" team in the Quantum and Molecular Optics laboratory. He is a junior member of the French "Institut Universitaire de France" since 2003, and Deputy Director of the ENS Cachan since January 2009. His research interests include single photon sources and their application to quantum cryptography, and the study of nonlinear optical effects at the nanometer scale.