From confocal microscopy to confocal OCT

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Confocal microscopy is a well-established technique in many fields, ranging from the biomedical to the engineering one, because of both its ability to image subsurface features selectively in depth and the improved lateral and axial resolution over conventional microscopes. A confocal microscope is a diffraction-limited scanning spot microscope in which both the light source and the detector usually take the form of micrometer scale pinholes. An image of an object is built up in a pointwise fashion by scanning the diffraction-limited spot across the surface of the object in a technique similar to that used in scanning-electron microscopy. The basis of operation of the confocal microscope is now well documented in the literature.[1-10]

The concept of confocal microscopy was described in 1961 by Minsky[11], but it was not until 1968 that the first practical instrument was built[12], and it is only in the last decade that confocal microscopy has become popular, particularly thanks to the use of optical fibers.[13,14] Although a number of commercially available confocal microscopes are now on the market, the technology is young and still evolving.

OCT is a relatively new high-resolution imaging technique which provides high resolution tomographic images of semi-transparent objects. The OCT technique was invented in the mid-1990s by Huang et al.[15], and since then has been widely applied in medicine and biomedical field for probing biological tissues.[15-17] It uses visible or infrared light to provide non-invasive cross-sections of partially transparent or scattering media.

Either commercial sources, such as superluminescent diodes,[18] or laboratory-based solid state lasers can be used,[19, 20] being the axial resolution determined by the bandwidth of the source. This latter generally falls into the range from 1 to 10 μm, even though the lateral resolution is significantly lower, usually no better than a few tens of micron, making the technique particularly well suited to inspect the internal structure of stratified objects.

Both techniques are harmless to all known types of artworks because the examination is non-contact, it does not require any preparation of the object examined and light of low intensity is utilized. The increasing emphasis on non-destructive testing in conservation and the demand for thorough characterization of artworks *in situ* can be met through the application of portable diagnostic methods such as OCT and confocal microscopy.

Up to now Optical Coherence Tomography has been successfully applied in the Cultural Heritage field for measuring the varnish thickness[21-30] whereas confocal microscopy is at its very early stages in this field, and no report can be found in literature of the use of confocal microscopy in cultural heritage field.

When measuring a highly reflective surface the microscope results in a marked intense signal that often hides the signal which comes from underlying surfaces. We decided, then, to modify the instrument transforming it in a confocal-OCT device: the optical launching/receiving system is the one of the confocal microscope but we put upstream a fiber optic coupler and we used a broad-band SLED.

This configuration, besides increasing the depth resolution, has the advantage to allow to maximize the signal scattered by the internal interfaces, where generally speaking there is a low refractive index variation and a huge diffusion.

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