Optical metrology for nanotechnology

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Production and environment require extremely large resolution and accuracy metrology, as the nanotechnology-based industry grow. Non-contact optical measuring systems on micron ranges are being extended to the nanometer scale to handle surface metrology and nanoparticles study. A comparative overview of known optical techniques and their future prospects will be presented.

Interferometry and confocal microscopy methods are the most used optical methods in the micrometric and submicrometric ranges. In interferometry, surface-dependent phase differences between a reference beam and a beam carrying information are translated into height information, with accuracies up to $\lambda/100$ or even below; limitations exist for height discontinuities in the measurement field, although low coherence light sources can overcome this problem. Confocal microscopy is the base of a variety of methodologies. Signal processing of the intensity patterns obtained along the surface, referenced to a particular plane where the system is focused, allows heights to be recovered, leading to accuracies in the nm range. Improvements with super-long working distance microscope objectives allow obtaining on-axis nano-accuracies. These techniques, don't deal well with in situ measurements, and new methodologies such as phase recovery methodologies are required to accomplish sub-μm and nm resolutions.

Some optical techniques can be used to measure particles greater than 1 μm, but few can be used for smaller (~10 nm) particles. The most used methods are Dynamic Light Scattering (DLS), Atomic Force Microscopy (AFM) and Laser Diffraction (LD). DLS (Photon Correlation Spectroscopy (PCS) or Quasi-elastic Light Scattering (QELS)), relies on Brownian motion of particles in a liquid (this can alter particles' characteristics) to determinate particle size; it is an ensemble technique with small measurement times and samples are very easily prepared [1]. AFM is a single particle technique, which can provide information about the surface structure; it requires well trained technicians to prepare the sample. LD methods, below the μm range, are based on Mie or Rayleigh theory but the analysis of diffraction patterns requires previous knowledge of the complex refractive index [2]. Commercial devices reach size measurements as lower as 30 nm. One can divide these methods in Microscopy (e.g. AFM/Scanning Tunneling Microscopy (STM), and electron microscopy), Sedimentation-Centrifugation (e.g. Cuvette photocentrifuge and X-ray disc centrifugation) and Light Scattering (e.g. DLS and LD) [2]. Other techniques can be found to measure nano-particles, although designed to obtain directly other characteristics, such as Raman scattering [3], which is also used in particle trapping (polymers and other organic materials) [4]. Their application for *in situ* monitoring will lead to further research.

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