Non-destructive in-line nano-metrology techniques for roll to roll nanoimprint lithography manufacturing processes

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Dimensional nano metrology plays a pivotal role in advancing nano manufacturing techniques by enabling precise characterization and quality assurance at the nanoscale. As nanotechnology continues to push the boundaries of material engineering, there is an increasing need for accurate and reliable measurement techniques capable of quantifying the dimensional properties of nanoscale structures. State-of-the-art dimensional nano metrology leverages cutting-edge technologies such as scanning probe microscopy, electron microscopy, and optical interferometry to achieve exceptional resolution and accuracy. These techniques enable researchers and manufacturers to quantitatively assess critical parameters including feature size, shape, surface roughness, and dimensional tolerances with unprecedented precision.

By providing detailed insights into the structural and dimensional characteristics of nanoscale components, dimensional nano metrology empowers researchers and engineers to optimize manufacturing processes, enhance product performance, and accelerate the development of next-generation nanotechnology applications across diverse fields including electronics, biotechnology, energy, and materials science.

In the work, we present a non-destructive dimensional metrological tool (Fig. 1) capable to provide real-time information on the critical dimensions and the evolution of the characteristics of the manufactured nanostructured materials. In particular, information on the thickness of the deposited and imprinted material in a roll to roll UV NIL tool is measured in real time at speeds of up to 5m/min. An important element for the measurements is that a neural network has been developed to predict pattern dimensions from a single reflectivity spectrum. Furthermore, the experimental validation of the metrology method is the precise control of the polymeric imprinting material thickness ranging from few hundreds of nano meters to 10's of micro meters thickness. For the scope of the metrology platform, UV curable resist materials, with certain optical and chemical properties, have been developed creating a database of features that will help in the comprehensive understanding and evaluation of the dimensional metrology platform.

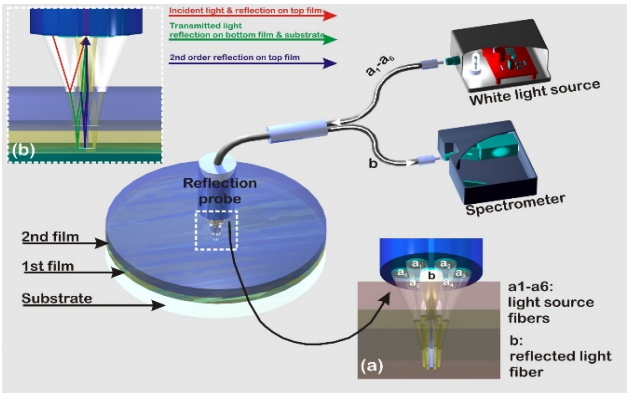

Figure 1. Schematic representation of White Light Reflectance Spectroscopy, (WLRS) for film thickness measurements.

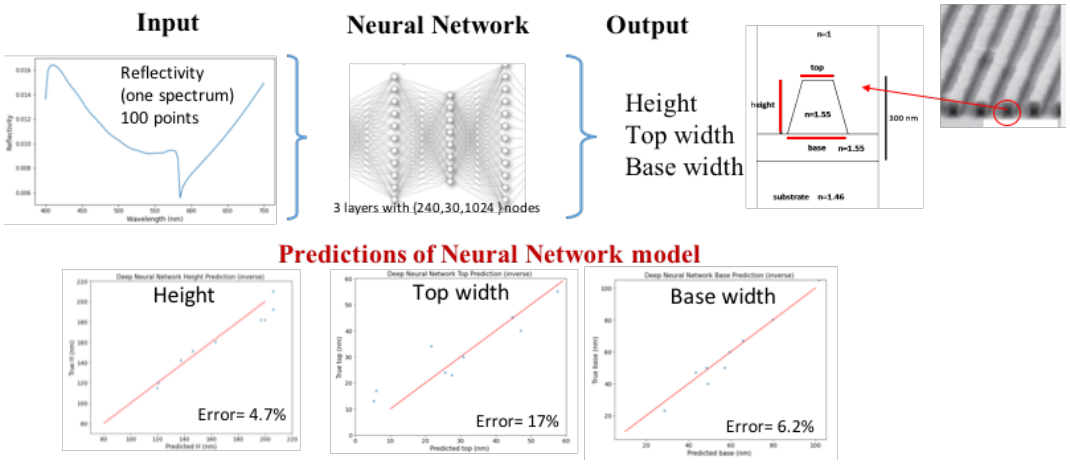

Figure 2. Training with data from electromagnetic simulations of reflection process .

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