Non-invasive Microwave Metrology Technique for $YBa_2Cu_3O_{7-\delta}$ Film Thickness

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We investigate a new non-invasive metrology technique that enables determination of the thickness of metal films and superconductor films from nanometers to micrometers at microwave frequencies by using dielectric cylindrical resonators. The working principles of microwave metrology are based on reflection of electromagnetic waves at the film-substrate interface having impedance mismatch and the natural equality between the intrinsic surface resistance and the intrinsic surface reactance for electrical conductors in the local limit. At first glance, microwave metrology technique seems similar to the four-point probe technique, a technique widely used in semiconductor industries, in that both methods measure resistance of metal films. However, looking into details, microwave technique is a lot different from the four-point probe technique in that, unlike the sheet resistance, the intrinsic surface resistance is determined without having to take the geometry of test films into account for films greater than a certain size. Also, unlike X-ray spectroscopic technique and opto-acoustic technique, no protective measure needs to be taken for users of microwave metrology technique. Here thickness of $YBa_2Cu_3O_{7-\delta}$ film and Pt films is measured by using microwave technique, which are compared with those as measured by using TEM and step profilometers.