BAM

Elektronenspektroskopie für die chemische Oberflächenanalytik (ESCA / XPS): Bestimmung von SiO_2-Schichtdicken auf Silicium

Schlagwörter

Schichtdicke, Silicium, Siliciumdioxid, ESCA, Nanotechnologie

Prüfgrößen und -objekte

Schichtdicken von SiO_2 auf Silicium

Prüfbereich	**Ergebnisunsicherheit**			
1 nm bis 10 nm	von	0,05 nm	bis	0,3 nm

Einsatzgebiete

Qualitätsbewertung anderer Verfahren zur Bestimmung der Schichtdicke

Charakterisierung von Referenzmaterialien für die Silicium- und Nanotechnologie

Prüfmethodik und Gerätetechnik

Quantitative Auswertung der Si 2p Photolinien der Schicht und des Substrats mit anschließender Berechnung der Schichtdicke unter Nutzung eines validierten Modells.

Qualifikation und Qualitätssicherung

Auditiertes Qualitätsmanagement-System (ISO 17025)

Verfahren validiert durch erfolgreiche Teilnahme am Key Comparison K-32 des CCQM/BIPM

CMC (SURF-01) Eintrag in der Key Comparison Data Base des BIPM

Verfahren genormt (ISO 14701:2011 Surface chemical analysis -- X-ray photoelectron spectroscopy -- Measurement of silicon oxide thickness)

Ansprechpartner:

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Fachbereich 6.1: Oberflächenanalytik und Grenzflächenchemie

Referenzverfahren auf www.rrr.bam.de

Ergänzende Angaben

Literatur

Surface and Interface Analysis (2009) 41, 430–439, DOI 10.1002/sia.30451

Ultra-thin SiO_2 on Si IX: absolute measurements of the amount of silicon oxide as a thickness of SiO_2 on Si, M. P. Seah, W. E. S. Unger, Hai Wang, W. Jordaan, Th. Gross, J. A. Dura, Dae Won Moon, P. Totarong, M. Krumrey, R. Hauert and Mo Zhiqiangj

Zusammenfassung

Results from a study conducted between National Metrology Institutes (NMIs) for the measurements of the absolute thicknesses of ultra-thin layers of SiO_2 on Si are reported. These results are from a key comparison and associated pilot study under the auspices of the Consultative Committee for Amount of Substance. ‘Amount of substance’ may be expressed in many ways, and here the measurand is the thickness of the silicon oxide layers with nominal thicknesses in the range 1.5 nm to 8 nm on Si substrates, expressed as the thickness of SiO_2. Separate samples were provided to each institute in containers that limited the carbonaceous contamination to approximately <0.3 nm. The SiO_2 samples were of ultra-thin on (100) and (111) orientated wafers of Si. The measurements from the laboratories which participated in the study were conducted using ellipsometry, neutron reflectivity, X-ray photoelectron spectroscopy or X-ray reflectivity, guided by the protocol developed in an earlier pilot study. A very minor correction was made in the different samples that each laboratory received. Where appropriate, method offset values attributed to the effects of contaminations, from the earlier pilot study, were subtracted. Values for the key comparison reference values (agreed best values from a Consultative Committee study) and their associated uncertainties for these samples are then made from the weighted means and the expanded weighted standard deviations of the means of these data. These results show a dramatic improvement on previous comparisons, leading to 95 % uncertainties in the range 0.09 nm to 0.27 nm, equivalent to 0.4–1.0 monolayers over the 1.5 nm to 8.0 nm nominal thickness range studied. If the sample-to-sample uncertainty is reduced from its maximum estimate to the most likely value, these uncertainties reduce to 0.05 nm to 0.25 nm or 1.4 % relative standard uncertainties. The best results achieve ~1 % relative standard uncertainty. It is concluded that XPS has now been made fully traceable to the SI, for ultra-thin thermal SiO_2 on Si layers, by calibration using wavelength methods in an approach that may be extended to other material systems.