EEE6009: Advanced Instrumentation Course (unit EM1-3) 21 February 2008

Title: Advanced Instrumentation – Electron Microscopy

Marking scheme:

marks	issues addressed in answer
5	BF image: upper layer shows diffraction contrast, hence the **upper layer must be crystalline**
5	BF image: upper layer appears dark, i.e. has higher mass absorption contrast, thus it is probable more dense and/or has **heavier atoms** in it
10	SAED from both layers reveals very similar structures typical of <110> zone axes in **cubic** structures (1:√2 aspect ratio, 2 mirror planes). Note that the projection is not hexagonal because there is no six-fold symmetry (though it may appear so at first glance)
10	SAED from interface region shows one common set of reflections, indicating **orientational relationship**
10	HREM image shows **perfect epitaxy** between two crystalline materials with very similar lattice fringe contrast. The upper layer appears somewhat darker, again indicating stronger scattering.
10	The **fringe spacings observed** in HREM are ~0.28nm and ~0.33nm, corresponding roughly to Si (200) and (111) planes, but could really represent almost any **semiconductor** (e.g. (Al)GaAs, Ge).
10	EDX spectrum shows presence of 6 lines. These **6 candidates** are: C (K-line, contamination), O (K-line, surface oxidation), quite strong but not directly identifiable line just below 1keV (Ni L-line, but could be any transition metal L-line (Co, Ni, Co); Ne K would make no sense for chemical compound), Si (K-line, strongest), Ni K line (second strongest; must be from sample), Cu (K-line, presumably from grid)
20	EELS reveals only Ni M and Si K edges, hence **no Co or Cu**; Ni and Si signals are both roughly equally strong, but as Si L has lower cross-section than Ni M there must be **more Si than Ni** in the sample
10	only Si and Ni with a bit of C and/or O are left as candidates, possible compounds: nickel silicides (silicon carbides and oxides would be lighter, contradicting the observed strong mass absorption contrast)
10	the **only nickel silicide that is Si-rich and has a cubic structure similar to the diamond lattice** of Si is $NiSi_2$ (CaF_2-type structure). So the structure should be $NiSi_2$ on Si, a system of great importance to the computer industry for fabrication of metal contacts onto silicon, e.g. for MOSFETs. Both are cubic face-centred structures with very similar lattice parameters of a_{Si}=0.5431nm and a_{NiSi2}=0.5406nm (the latter is only 0.5% smaller).

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