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A model for atomic transport induced ion mixing at high temperature

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When a bilayer system is irradiated with ion, atomic transport at the interface proceed with following three steps.

i) Cascade mixing
ii) Thermal spike mixing
iii) Radiation enhanced diffusion (RED)
or Radiation induced segregation(RIS)

The models for cascade and thermal spike mixing were examined by surface lab. in Yonsei Univ. [1], [2], [3]

For RED(or RIS), though many researchers have been studying, various systems could not be explained by their theories.

To exclude chemical effect, we choose the Pd/Co system which forms solid solution through all the concentration. Pd(350 Å)/Co(350 Å) was deposited on Si(100) by E-Beam evaporation and irradiated with 80keV Ar^+ ion at different temperature. The amount of atomic transport was measured by RBS and analysed by using overlayer method.

Our model for temperature dependent atomic transport is as follows.

$$J_{A(B)} = \omega\, a_B^4 \sqrt{\frac{F_d}{E_d}\frac{d}{dt}\phi}\ \exp\left[\frac{0.03E_{coh}^{B} - 0.14\,E_{coh}^{A}}{k\,T}\right]$$

$J_{A(B)}$: flux of A element to B layer
ω : constant
a_B : hopping distance
F_d : average deposited energy at the interface
E_d : displacement energy of A material
$\frac{d}{dt}\phi$: Ion flux
E_{coh}^{i} : cohesive energy of i element

We found the ratio of $J_{Pd(Co)} / J_{Co(Pd)}$ at different temperature, the activation energy and critical temperature from experiment, and compared with the theory.
Our theory was correspond to not only Pd/Co system but also other systems very well.

Reference
[1] Nucl. Instrum. Methods B, To be published
[2] K. H. Chae et. al., J. Kor. Phys. Soc. 26(6), 622, (1993)
[3] K. H. Chae et. al., J. Appl. Phys. 73(9), 4292, (1993)