Angular Distribution of Sputtered Cu_xAl_y Alloys: Simulated Study

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Abstract: Angular distribution of Cu and Al from CuxAly alloys are calculated. The simulated sputtered material is collected from an imaginary cylinder surrounding the fictive targets. The simulation was done with the well-tested SRIM-code for a large number of incident ions (5 keV Kr+) and let the computer count the number of Cu and Al toms emitted in the solid angle corresponding to each probe. Furthermore, angular distribution of differential sputtering yields of both Cu and Al showed cosine and over-cosine tendency.

1 INTRODUCTION

The interaction of an ion beam with a solid target guide to the phenomenon of sputtering, i.e. The ejection of atoms and their aggregates according to the target (Ming, 1991; El Boujlaidi et al., 2012; Jadoual et al., 2014; Cortona et al., 1999). Sputtering put in various fields, such as surface analysis, depth profiling, sputter cleaning, and sputter deposition. Sputtering has become an essential tool in such modern technologies as the deposition of high-quality thin films on almost any substrate, depth microanalysis, surface cleaning and micromachining (Dogar and Qayyum, 2006). Experimental and simulation studies of angular distribution are widely used in the literature (Behrisch and Wittmaack, 1991). For example, Chernysh et al. (Chernysh, et al., 2004) bombarded Si and Ge targets with 3-10 keV Ar+ ions and determined the angular distributions of sputtered atoms using Rutherford backscattering analysis. The collector was made of beryllium foil and had a semi-cylindrical shape with a radius of 15 cm. In Ref. (Verdeil et al., 2008), silicon, germanium and indium phosphide targets were sputtered with a 2-10 keV Cs ion beam in the range of the incident angles of 30-60°. Emitted particles were collected on a semi-cylindrical copper foil. In Ref. (Ait El Fqih, 2010), the angular distributions of Cu and Be atoms sputtered from $Cu_{98}Be_2$ alloy under 5 keV Kr^+ ion bombardment were measured at different angles of incidences.

The purpose of this study is to report a new computational result on angular distribution of sputtered Cu and Al from a Cu_xAl_y alloy targets under 5 keV Kr+ ion bombardment.

2 SIMULATION

The simulation used was the well tested computer SRIM-code (Ziegler and Biersack, 1985). For a large number of incident ions, the computer counts the number of copper atoms emitted in the solid angle corresponding to each simulated square side (probe). SRIM software provides information including the total sputtering yield as well as ion implantation into the target. One of the main approximations known in this software consists in the surface of the target which becomes smooth again after each ion impact. In SRIM calculation, ZBL potential is used. The ratios of Cu atoms emitted in the solid angle were counted. The SRIM software requires the introduction of several parameters, the simulation conditions considered arethat usually used in various experiments. Some of them, like energy and incidence angle of the ions, are obtained experimentally. The raw data obtained from SRIM

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software are processed by another software, called Angulaire [11]. Indeed, the SRIM givesinformation only on the velocity of ejected particles and not on their numbers. Hence, an analytical treatment is undertaken through a mathematical formalism, via Angulaire, to find the sputtered products.

3 RESULTS AND DISCUSSION

Note that the square side in the cylindrical (Mylar) foil is called b and the arc delimited by the square in the z-direction depends on the angle μ. We denote by z_0 the value of z at the center of the square, and by $\mu_0 = 0$ the value of μ at the center. The variation domain of the angle μ is then $[-b = (2r); +b = (2r)]$ and for z is: $[z_0 - b = 2; z_0 + b = 2]$. The solid angle Ω under which we see the square from point O can be written as [11]:

$$\Omega(z_0) = \int_{\frac{-b}{2r}}^{\frac{b}{2r}} du \int_{z_0-\frac{b}{2}}^{z_0+\frac{b}{2}} dz \frac{r^2}{(r^2+z^2)^{\frac{3}{2}}}$$

Figure 1 shows the angular distributions of relative sputtering yield of Cu and Al particles from a sputtered $Cu_{90}Al_{10}$, $Cu_{50}Al_{50}$ and $Cu_{10}Al_{90}$ target obtained for 5 keV Ar^+ ions bombardment for aseries of surfaces along, the x-axis as a function of angle μ. Dotted lines are the best-fit curves determined using the cosine fitting function:

$Y(\theta) \propto \cos^n(\theta)$

where Y is the angular distribution, θ is the angle of emission and n the cosine exponent. The distribution curves exhibited an under-cosine (n < 1) tendency.

Previousexperimental observations and computer simulations established over-cosine distribution is a rather general feature in the cascade regime [12 -13]. The origin of the unregister tendency is attributed to the linear-collision cascade theory.

4 CONCLUSIONS

In summary, angular distributions of sputtered Al and Cu particles from a sputtered Cu_xAl_y target was studied by computer simulation for the case of 5keV Ar^+ ion bombardment at normal incidence. The angular distribution of the sputtering yield exhibits an under-cosine tendency for x-axis and attributed to the linear-collision cascade theory and to a surface-induced anisotropy in the recoil flux below the surface, or to an anisotropic surface scattering of an isotropic recoil flux.

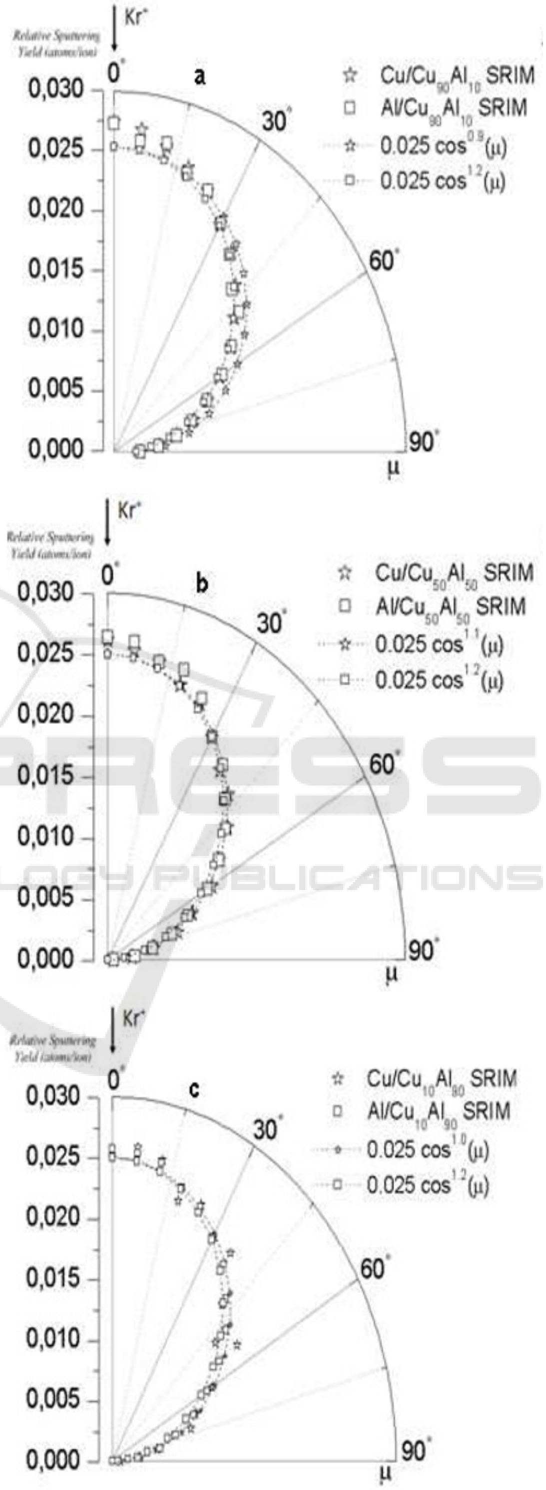

Figure 1: Simulated angular distribution of sputter-ejected Cu and Al particles from Cu_xA_{ly} alloys target sputtered with 5 keV Kr+ ions.

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