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SUMMARY OF RESULTS OF THE PROGRAM

Au and Au-Alloy/SiC systems

Studies were performed of the Au/SiC interface, as well as the interfaces between SiC and several Au alloys. (The Au/SiC system is potentially interesting for the metallization of semiconductor SiC). High quality micro-crystals of pure Au were prepared on the surface of 6H-SiC. A contact angle of 133°±1° for pure Au on SiC was obtained after equilibration at 800°C. Three elements were identified as having potential to segregate to the Au-SiC interfaces thereby increasing interfacial adhesion: Sn, Ge and Si.

Au containing 3at%Sn was studied, and wetting was improved as evidenced by a decrease in contact angle from 133° for pure Au to 117° for the Au-Sn alloy. Sn segregation was observed at the surface of Au. However, the decrease in contact angle can only occur if there is also substantial segregation of Sn to the Au/SiC interface. Independent evidence of the presence of Sn at the Au-Sn/SiC interface was obtained by the so-called Crater Edge Profiling (CEP) technique.

Measurement were also performed on Au-Ge alloys. Here it was found that the contact angle is decreased to 115° and 107° at Ge concentrations of 1 and 2at%, respectively. No segregation of Ge was observed at the surface of Au, indicating that the decrease in contact angle can be ascribed entirely to the segregation of Ge to the interface. Evidence of Ge segregation to the Au-Ge/SiC interface was also obtained by CEP.

Finally, studies of Au containing a low concentration of Si (~0.5 at%) were also conducted and showed a decrease in contact angle from 133° to 107°.

Table 1 Work of adhesion of Au and Au alloys on α-SiC

	Contact angle (degrees)	Surface energy (mJ/m^2)	Work of adhesion (mJ/m^2)
Pure Au	133	1400	445
Au-4.0at%Sn	117	970	530
Au-0.5at%Si	107	1400	990
Au-1.0at%Ge	115	1400	810
Au-2.3at%Ge	110	1400	920
Au-5.8at%Ge	107	1400	990

All of the results are summarized in Table 1. The table shows that the work of adhesion of pure Au on SiC can be doubled by small additions of Si or Ge. Sn is less effective in increasing the work of adhesion because it segregates both to the surface and the Au/SiC interface, thereby offsetting the effects of interfacial segregation. Thus, two important conclusion can be drawn from this work. (a) Significant changes in the work of adhesion can be achieved by alloying the metal phase with elements which segregate to the interface, without forming possibly deleterious interfacial reaction products, and (b) that elements which selectively segregate to the interface, without segregating to the surface of the metal phase (or the surface of the substrate) are more effective in improving interfacial adhesion.

Equilibrium crystal shape (ECS) of Pure Au and Surface Energy Anisotropy.

Au crystals equilibrated on SiC substrates display extremely clean surfaces and are thus particularly suitable for studies of the equilibrium crystal shape (ECS) of Au. Consequently, the ECS of Au was determined. The results showed: (a) that the presence of C at the Au surface has a measurable effect on the anisotropy of surface energy, (b) that the shapes of the arcs connecting {111} and {100} facets are indicative of the existence of short-range attractive step-step interactions and long-range repulsive step-step interactions, and (c) that the orientations of surfaces in equilibrium with the edge of {100} facets are consistent with previous predictions of the existence of so-called "magic" vicinals at {11 1 1} orientations.

Pb(Ni)/Graphite System

The wetting of graphite by Pb(Ni) alloys was investigated. A new technique was developed to produce samples exhibiting a continuous change in Ni concentration from 0% to 0.30%Ni. This approach yielded much more detailed information on the contact angle variation of Pb(Ni) on graphite, as a function of Ni concentration, than had been previously available. The results showed that contact angles of 100° and 80° coexist in the vicinity of the limit of solubility of Ni in Pb (~0.17%Pb), without intermediate contact angles being present. This demonstrates the presence of a first order transition in contact angle associated with precipitation of Ni at the Pb/graphite interface. As far as we are aware, these results are the first to show evidence for such a transition in solid/solid interfacial systems. In addition, since this transition is associated with a significant increase in work of adhesion, interfacial precipitation appears to represent an interesting (previously undocumented) approach for controlling interfacial adhesion.