CHAPTER IV

EXPERIMENTS WITH VANADIUM, TANTALUM AND Nb_NAl_M

In the present chapter we extend our study to tantalum, vanadium [W.A. de Heer, 2003b] and the binary alloy Nb_NAl_M.

4.1 Electrical Polarizabilities of Vanadium and Tantalum Clusters.

At room temperature, the deflections of vanadium and tantalum clusters follow a quadratic dependence on the field, so they are polarizable particles. Results are shown in figure 41 for vanadium and figure 42 for tantalum. In both cases the polarizabilities are higher than the bulk value. Using equation 6 to fit the data we get 0.18 nm for δ in vanadium and 0.19 nm in tantalum. These values are so large that some clusters have polarizabilities of 4 times the bulk value. In the case of niobium (figure 19) δ is 0.1 nm, which accounts for polarizabilities of 2.5 times the bulk value. When cooled down vanadium and tantalum clusters develop permanent dipole moments as seen in niobium, however it happens at lower temperatures as will be shown below.

4.2 Low Temperature Results with Vanadium and Tantalum Clusters

Vanadium and tantalum clusters develop tails at low temperatures, similarly to what we observed in niobium, and a good fraction of the clusters are deflect beyond the detector limits. Figure 43 shows the ferroelectric fraction measured at 18 K in vanadium clusters and figure 44 is the result of an experiment at 21 K with tantalum. Notice that clusters with even number of electrons in general show larger values of R.

If we apply the model proposed for niobium we could use these results to estimate the transition temperature. Assuming that the values of R are already saturated at 80 kV/cm we can use equation 19 to get T_G. Figures 45 and 46 show the calculated values for vanadium and tantalum respectively. It can be seen that in both metals T_Gs are lower than in the case of niobium. Several features are similar between these metals, for example V_{13} and Ta_{13} are normal (They have no permanent dipole moment, hence R=0) but V_{14} and Ta_{14} have a T_G of 14 K, which is the maximum in both cases. Notice also that a common feature of the three metals is that there is a sharp transition at 28 atoms.

4.3 Results with Nb_NAl_M

We run an experiment using a sample made of the alloy $Nb_{0.7}Al_{0.3}$ and it made binary clusters with several compositions. Because Nb_3Al is a superconductor at 17.5 K [Kittel, 1996] we wanted to see the effect of adding aluminum atoms to a niobium cluster. Figure 47 shows our results for $Nb_{15}Al_M$. Other clusters were affected in less degree, but the general trend was that adding aluminum enhanced the ferroelectric effect.