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Growth and Magnetism of Ni nanoparticles on n-Si(111)

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Nanocrystalline Ni Thin films were directly grown on n-Si(111) substrates by pulsed electrodeposition. The size of Ni crystallites formed increased with a increase of frequency of potential pulses. When the frequency is varied from 20 to 900 Hz, the average size of Ni nanocrystallites ranges from 48 to 131 nm. At the frequency of 1200 Hz, continuous Ni films due to coalescence of individual Ni crystallites were grown on Si substrates. In this experiment, it has been found that the frequency of potential pulse is a very important parameter which can be control the size of the nanocrystallites. The average size at the frequency of 600 Hz was 86 nm and at this frequency, Ni nanocrystallites was nucleated with instantaneous growth mode which is 3-dimensional islands followed by diffusion limited growth.

Vibrating sample magnetometer(VSM) results have shown that the coercivity of as-deposited samples depends significantly upon the size of Ni nanocrystallites. The perpendicular magnetization ($H_{C,\perp}$,) shows the rectangular-like hysteresis curve but the parallel magnetization($H_{C,\parallel}$) showed the nonrectangular hysteresis curve. In a case of $H_{C,\perp}$, the maximum coercivity, 203.5 Oe was observed at the average size of 86 nm. It is found that $H_{C,\perp}$ increases with the increase of the size until it reaches a maximum value at the critical size, and then it decreases with the increase of the size. This behaviors of $H_{C,\perp}$ represents the size dependence of magnetization processes. However, in contrast to perpendicular coercivity, $H_{C,\perp}$, the horizontal coercivity, $H_{C,\parallel}$, increased monotonically with increasing the sizes of Ni nanoparticles with the ranges from 40 nm to 130 nm but increased abruptly for the case of a continuous Ni film. In a case of continuous Ni films, the maximum coercivity was 440 Oe. As a result, it has been found that the horizontal coercivity, $H_{C,\parallel}$, can be affected by the different morphology between discrete Ni film consisted of isolated nanoparticles and a continuous Ni film.