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Comparing amorphous silicon prepared by electron-beam evaporation and sputtering toward eliminating atomic tunneling states

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ABSTRACT

It has previously been shown that amorphous silicon (*a*-Si) thin films can be produced free of tunneling two-level systems (TLS) by *e*-beam evaporation onto substrates held at elevated temperatures, and there appears to be a strong anticorrelation between the atomic density of these films and the number density of TLS. We have prepared *a*-Si films with higher atomic density using magnetron sputtering at substrate temperatures comparable to those used in the *e*-beam studies. We compare the atomic densities measured using Rutherford backscattering and the shear moduli, the speeds of sound, and the densities of TLS calculated using internal friction measurements at cryogenic temperatures of sputtered *a*-Si films to those of the *e*-beam films. Our results show that despite their higher atomic densities, sputtered *a*-Si films prepared at elevated substrate temperatures have lower speeds of sound and higher densities of TLS, which we attribute to the different film growth mechanism from that of *e*-beam evaporation. We conclude that a collaborative improvement of both local structure and network connectivity, determined by atomic density and speed of sound, respectively, to approach their crystalline values is required to eliminate atomic tunneling states.

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