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Characterisation of remote plasma sputtering of copper oxide thin films for functional applications

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To deposit high quality thin films, it is essential to have close control of as many deposition parameters as possible. The proprietary High Target Utilisation Sputtering (HiTUS) process uses a remotely generated high density plasma (>1013cm-3 ions) produced in a side arm adjacent to the deposition chamber. As this plasma is not driven from the target, it is possible to independently control the target voltage and ion current. This technology is particularly well suited for reactive sputtering due to the virtual elimination of target poisoning since the surface of the target is uniformly eroded. The system does not require any optical feedback systems or pulsed DC. This not only results in a stable process but also enables high rate, low temperature deposition onto flexible substrates.
In recent years Cu2O has become of significance again for semiconductor applications due to the relatively low cost of the native metal, non-toxic nature and high absorption coefficient in the visible range. Furthermore, copper oxide is of interest for functional applications as it has been observed that by varying the oxygen partial pressure during reactive deposition, thin films can be deposited which exhibit either p-type or n-type conductivity and high Hall mobilities. Cu2O is currently being researched for use as a p-channel layer in an oxide based high performance thin film transistor.
In this work, the HITUS process was employed to deposit copper oxide films at room temperature onto Si, glass and flexible substrates. The influence of oxygen partial pressure on the chemical composition and microstructure was studied using XPS, EDX and XRD. These results were correlated with the electrical properties. It is shown that as the oxygen partial pressure increases there is a progressive increase in the conductivity (opposite to most results in the literature) and the crystallographic structure changes from Cu2O through Cu4O3 to CuO. This is the first time Cu4O3 (parmelaconite) has been directly deposited. The conduction mechanism switches between n-type and p-type depending on the oxygen concentration and relatively high Hall mobilities are observed for all films.

Keywords
Thin films