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Current-induced structural changes in stressed silver nanowires

Silver (Ag) nanowires (NWs) are a potential replacement of indium tin oxide films as conductive transparent electrodes in touch screens and solar cells. Ag NWs have excellent electrical (e.g. high resistance to electromigration) and optical properties, are easy to process and would enable bendable devices. To understand their response to extreme current densities and improve the overall stability of devices, the failure mechanism of Ag NWs has been studied under different conditions in this work.[1-3] When subjected to a high current density, a straight Ag NW breaks down following a common needle-type failure (**Fig. 1**). While literature extrapolates this for devices, in reality, when NWs are processed to form layered electrodes, a number of them will be bent. Expectedly, a finite amount of internal stress is generated in the NW depending on the degree of bending. Therefore, it is important to investigate the stability and failure mechanisms of bent NWs under the influence of current. Here, we employed transmission electron microscopy (TEM) to study the vibration, self-oscillation, electromigration and stress relaxation (through elastic and plastic deformation) of Ag NWs under the influence of both current and mechanical stresses (**Fig. 2**). The response of the bent NWs is significantly different from the straight ones both in failure mechanisms and restructuring capability.

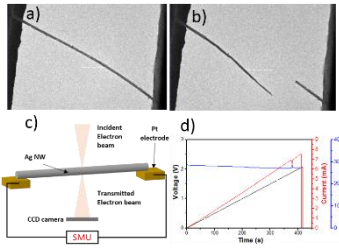

Figure 1: (a)-(b) TEM images of a Ag NW before and after failure due to Joule heating, (c) Schematic of the setup for in-situ TEM electrical characterization, (d) Voltage (current, resistance) vs. time curve.

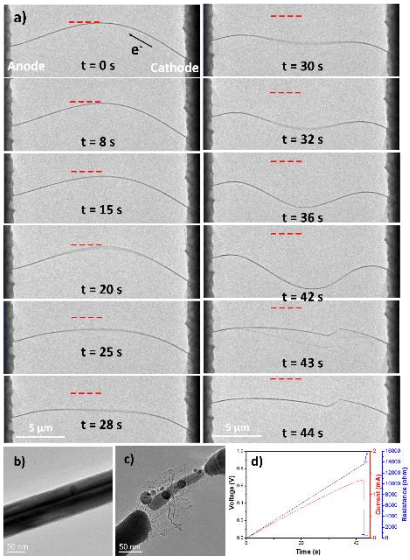

Figure 2: (a) Time-series of TEM images for the current-induced restructuring of a bent Ag NW (estimated bending strain of 0.21% and bending stress of 165 MPa) - the red dotted lines acts as a visual guide; (b)-(c) high magnification TEM images of the Ag NW in (a) before and after failure, respectively; (d) Voltage (current, resistance) vs. time curve.

References

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