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IN-SITU OBSERVATION OF THE ONSET OF PLASTIC DEFORMATION BY PRISMATIC LOOP EMISSION

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We report direct observations on the incipient plasticity of dislocation-free single crystal Au [110] nanowires by *in situ* transmission electron microscopy nanomechanical testing. The diameter of the tested nanowires ranged from ~ 80 nm to 350 nm and the length-to-diameter ratio was larger than 5. The top end of all [110]-oriented Au nanowires is bound by two inclined {111} faces in a wedge shape, on the other hand the side faces consist of four large {111} and two small {100} planes, resulting in a truncated rhombic cross-section. In our deformation setup where the wedge-shaped growth end of nanowire was compressed with a flat diamond punch, the strain becomes localized to the region under the contact. Under such a strong strain gradient condition, the initial compressive deformation began with the emission of small prismatic loops from the top corner, which have a radius ranging from ~20 nm to 100 nm. The Burgers vector of these loops was determined to be 1/2[-1-10], which generates the vertical downward displacement of the inner area encompassed by the prismatic loops. Right after the nucleation, these prismatic loops glided immediately down to reach a certain position where it remained stationary until newly generated loops force to glide downward in jerky manner. After a certain number of closed loops being punched out (typically less than ten), there was a clear transition in the nucleation mechanism of the loops; open loops started to bulge out and then released from the contact area. Very different from the closed prismatic loops, the freely moving ends of the open loops intersected and swept across the top faces before being released, thereby relaxing the strain accumulated beyond the contact area. The stress field accumulated inside the nanowire is also released by escape of open loops through the free surface. More importantly, these loops can act as sources for ordinary dislocations which slip along the inclined {111} planes. Based on the direct observation of prismatic loops and supporting molecular dynamics simulations, detailed characteristics of the loops and their behaviors at the initial stage of deformation of nanowire will be presented.