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TiN Hardmask Wet Etching and Post Etch Residue Removal in BEoL for advanced Technology nodes: Effects of material deposition and etch compositions

Andreas Klipp[a], Johan Hoogboom[a], [a]Electronic Materials, BASF SE, Ludwigshafen, 67056, Germany. (e-mail: * andreas.klipp@basf.com)*

In the semiconductor industry, titanium nitride is often used as an inorganic hard mask, enabling the robust creation of structures (vias and trenches) with widths down to at least 5 nm. After the vias and trenches are created, using plasma etching techniques, the hard mask has to be removed again by a wet chemical process, as its presence during final manufacturing steps would severely impact device performance or would increase process complexity in the subsequent process steps.

As the trench width is continuously decreasing with advanced technology nodes, the aspect ratio (depth to width) is increasing and can also lead to severe pattern collapse in BEoL. The selective removal of the titanium nitride hardmask after patterning can help to minimize pattern collapse and also reduce the aspect ratio in order to improve gap fill performance of the subsequent metallization process like electroplating copper or cobalt deposition.

In general, the TiN layer is removed using oxidative wet etching chemistry. With differentiation between chip manufacturers increasing over the past years, multiple types of TiN are used, mostly differing in deposition technique (Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD) and Atomic Layer Deposition (ALD)) and material composition (ratio between Ti : N : O : H). These different types of TiN hard masks show vastly differing wet etch rates and underlying mechanisms.

In this paper, we present data on the oxidative wet etching of different TiN hard masks, in which the deposition techniques and conditions were varied (PVD, CVD, ALD), as well as the oxidative wet etching chemistry. We discuss the impact of the deposition technique and composition on the etch rates, film morphology, thermodynamic parameters and underlying mechanisms for various products, and show that tuning of both the TiN film composition and the applied etch product results in a broad range of applicable chemistries which can be used in cutting-edge chip manufacturing technologies.

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