Methods for Removing TiOx Residue from Au Bonding Pad

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In the deposition of Au for bonding pads and interconnecting lines, a thin layer of Ti is added to increase the adhesion to subsequent layers. It is found that TiOx on the bonding pads reduced the wire bond strength and so processes were developed at GCS to remove the residual TiOx. The TiOx removal is after a PECVD-SiNx via etch that exposes both GaAs and Au/TiOx surfaces, so the desired clean-up process must not etch GaAs. Methods explored are dry etching using SF6 and CF4/O2, Ar sputtering, and wet etching using various acids. Ar sputtering and dry etch with SF6 and with CF4/O2 were able to remove the surface layer TiOx and any diffused TiOx. Acid wet etches were able to remove TiOx at over 200Å/hr; however, unlike dry etching and sputtering, wet etching could not penetrate beyond the Au/TiOx surface layer to remove diffused TiOx. For grain boundary diffusion of Ti in gold thin films at 200-400˚C, a diffusivity pre-exponential factor of $5x10^{-8}cm^2/s$ and activation energy of 0.54-0.66eV has been reported[1].

The thickness of the TiOx diffusion layer depends on the heat budget of the processes after the Au-Ti metal deposition, so over-etching or over-cleaning will always be needed as a safeguard. In addition to reviewing the efficacy of each method in removing TiOx, manufacturing considerations such as throughput and ease of process control will also be considered.

The effects of TiOx on the bond strength of Au bonding pads, with the TiOx as a thin surface layer and as a diffused layer, will be discussed using bond pull test data and cross-sections (data not shown below).

References

1. Martinez, W. E., Gregori, G., & Mates, T. (2010). Titanium diffusion in gold thin films. *Thin Solid Films*, *518*(10), 2585-2591.

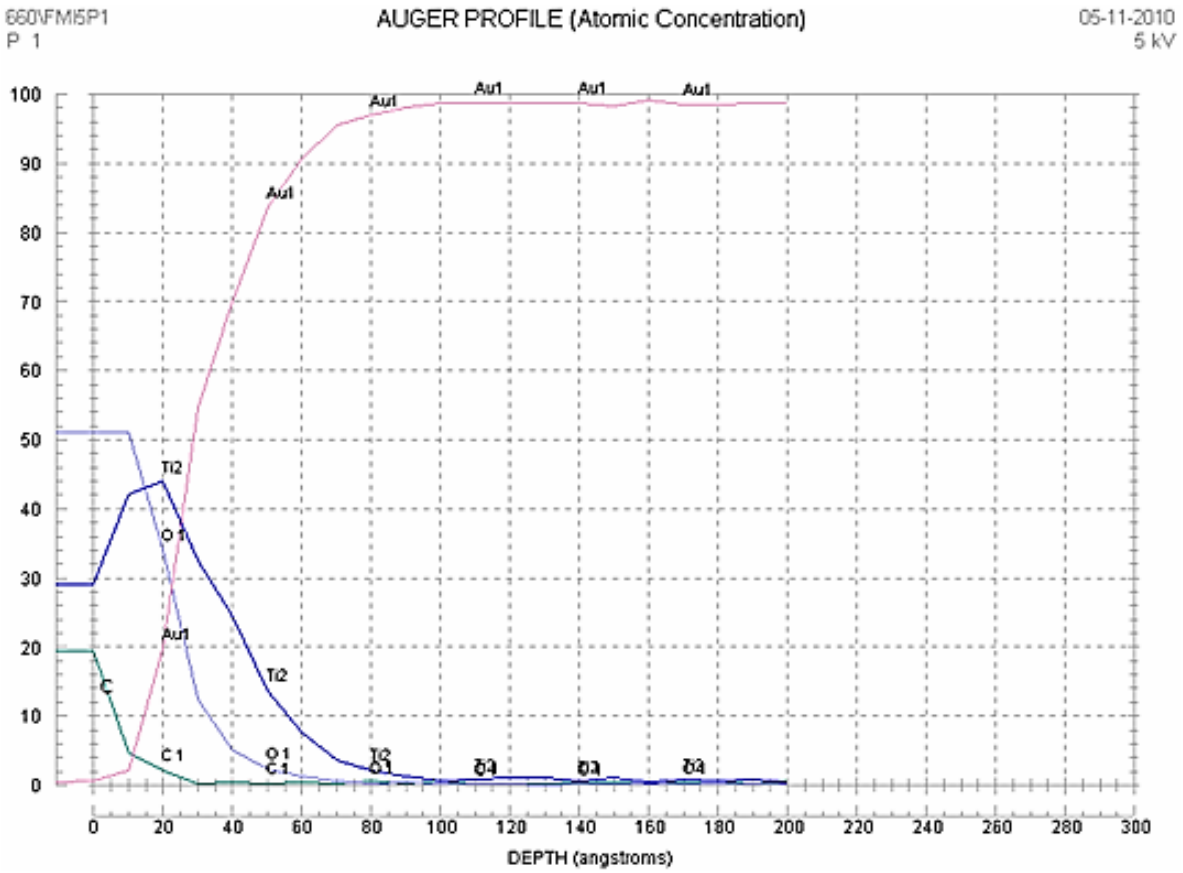

Figure 1: Auger profile of bonding pad without any processing to remove Ti.

The bonding pad consists of 30A Ti on top of 1.6um Au. The Ti signal was detected along with Au signal for up to a depth of 100A.

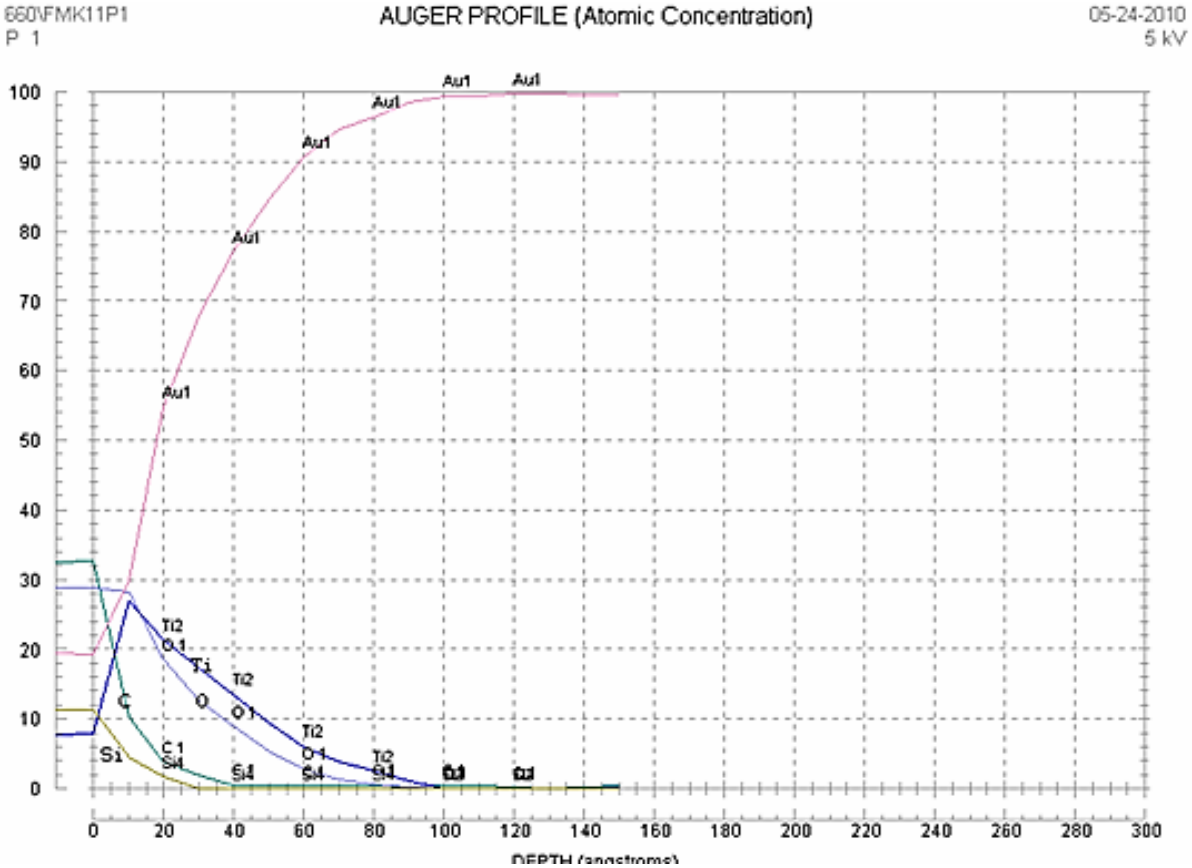

Figure 2: Auger profile of bonding pad after Ar sputter

By comparing the Ti/Au ratio with that on an unprocessed standard sample, about 15A was removed with 1minute of sputtering.

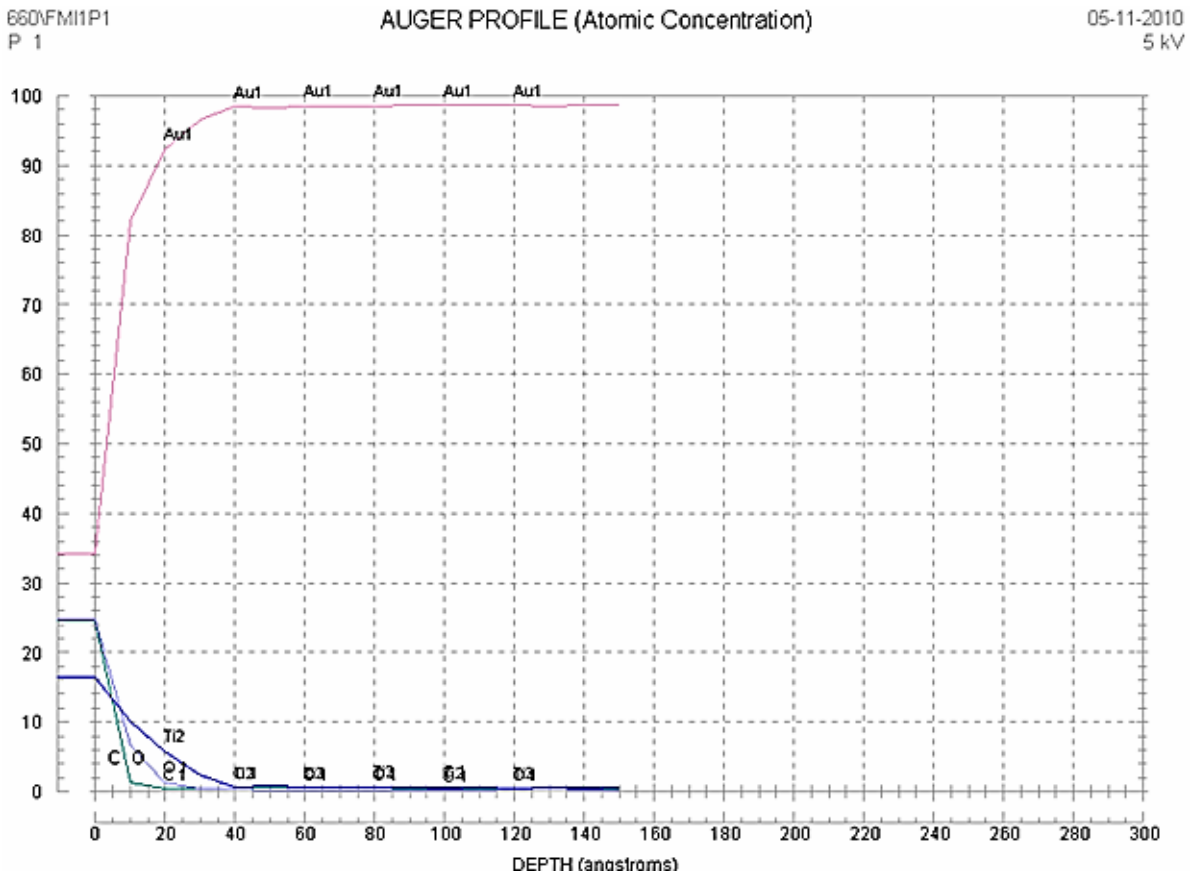

Figure 3: Auger profile of bonding pad after SF6 dry etch

By comparing the depth of Ti signal with that on the unprocessed standard sample, about 50A was removed with 7min of etching.

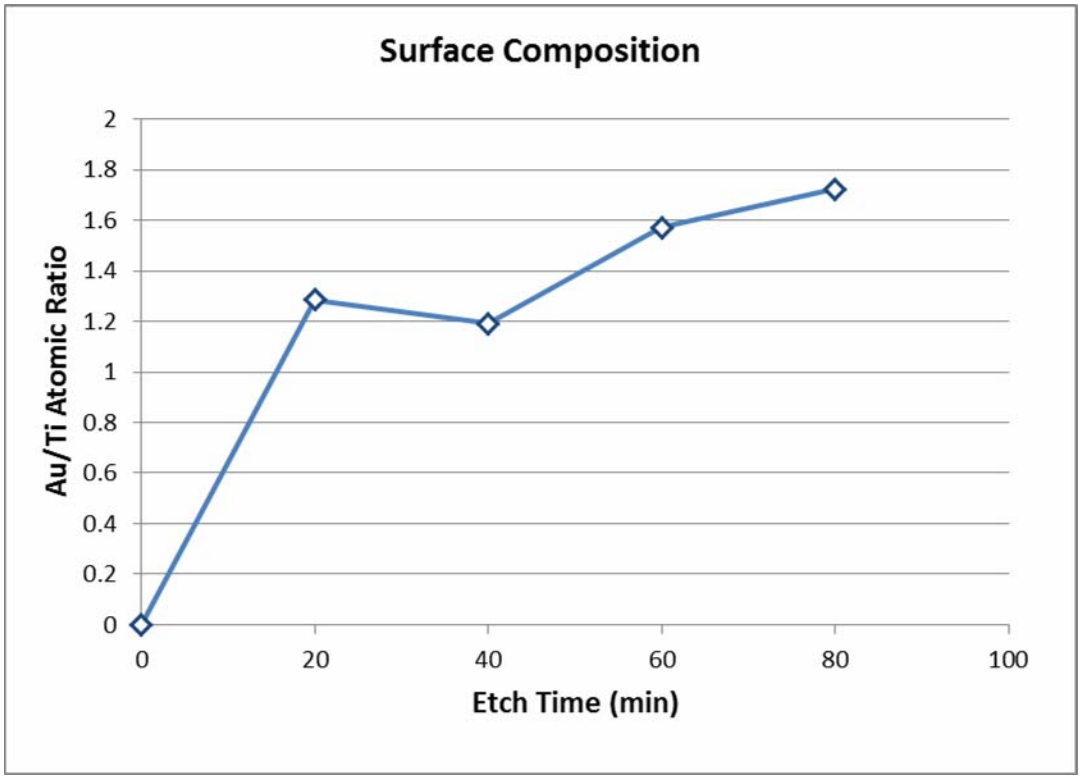

Figure 4: Au/Ti surface composition ratio of bonding pad after concentrated acid wet etch

As Ti is etched, the underlying Au is exposed, thus increasing the Au/Ti ratio. The Ti removal rate then decreases as the top layer of TiOx is depleted. The Au/Ti ratio is calculated using atomic composition from Auger Spectroscopy.