To Improve E-beam T-gate Yield by Pre-Cleaning Process

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Abstract

Bi-layer photo resistance of PMMA/PMAA is a well studied configuration for forming an E-beam T-gate of GaAs semiconductor process. However, this configuration is still without perfect property of slope of photo resist sidewall to avoid the metal stringer issue owing to the traditional metal lift-off process as show in Figure 1. Figure 2 illustrates the mechanism of the metal stringer owing to the angle evaporation during the metal deposition in evaporator, where the metal will be coated on sidewall of photo resist and the traditional lift-off process by using the non-spray type Acetone solution remove the rest photo resist could not effectively take away the metal stringer as well as photo resist. Typically, those remain metal stringer will potentially cause the higher leakage and lower breakdown behavior of the transistor as show in the Figure 3.

In order to remove remain metal stringer, the high spray type lift-off process with selective wet solution to take away that will be the main idea in this study. However, the spray type lift-off process will most likely cause the physical damage of the weakest point of metal T-gate structure such as foot print and neck if there is no any protected material covering the bottom part of the T-gate. In order to breakthrough this trade-off of two process window, the high spray IPA cleaning plus post ACE soaking process is developed as a new lift-off process to overcome the metal stringer issue and avoid the physical damage of gate during the high spray type wet chemical cleaning simultaneously. Since the IPA will not resolve the photo resist of PMMA or PMAA, the maintained photo resist could be a protected and naturally well protect the T-gate's weakest part including the foot print and gate neck even there is spray type IPA cleaning the wafer for the purpose of taking away the metal stringers as shown in the Figure 4. From the Figure 5, the less or no metal stringer could be significantly observed through the SEM inspection across whole gate region no matter on top of gate or semiconductors.

The gate leakage and breakdown dc sorting on one test circuit is defined as the test vehicle to correlate the yield improvement vs. the lift off approach. Figure 6(a) shows the sorting map of the wafers processed by standard pure ACE soaking type lift-off process, and the dc yield loss is located on the edge of wafer caused by metal stringer issue. Typically, the edge part of wafer usually will be processed with larger angle evaporation during the gate metal deposition, and the metal stringer issue will be relatively more serious than the center part of wafer where the no angle evaporation will not coating the metal on the sidewall of photo resist. Meanwhile, Figure 6(b) shows the good die map of wafer processed by the new lift-off approach of using spray type IPA cleaning plus post soaking ACE cleaning, and we could observe the yield loss of gate leakage

and breakdown is significantly improved especially for the edge part of wafer. The angle evaporation is identical as the wafer process by traditional lift-off process, but the removing of metal stringer will reduce the yield loss of gate leakage or low breakdown of tested circuit.

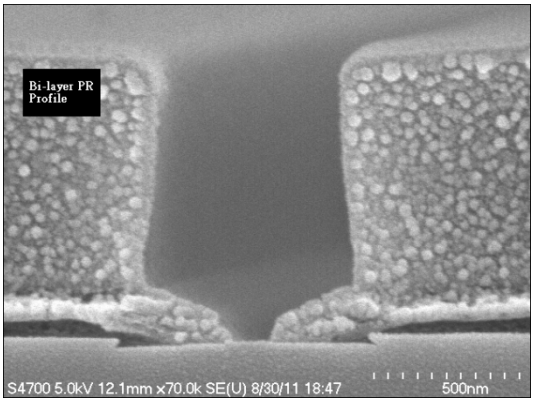


Figure 1, The bi-layer resistance profile of e-beam lithography technology.

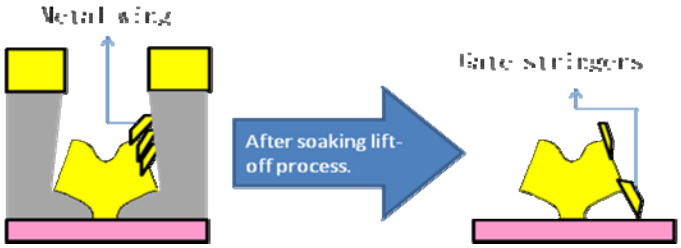


Figure 2, The mechanism of metal stringer.

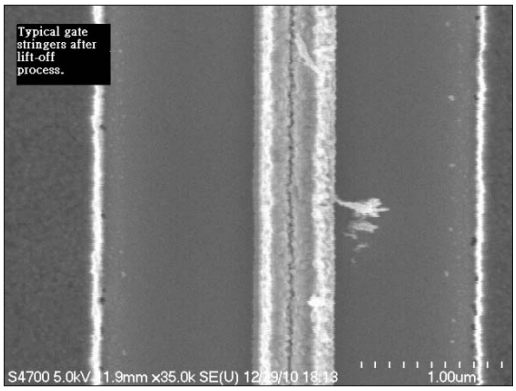


Figure 3, The photo of stringers on top of gate, and between gate and semiconductor

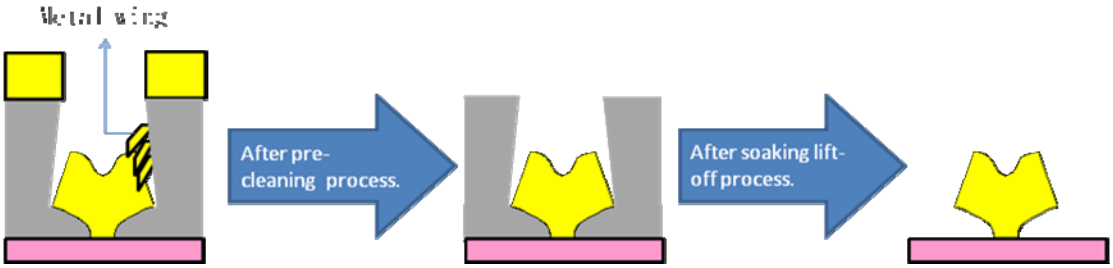


Figure 4, The concept of IPA spray type clean plus ACE soaking type clean

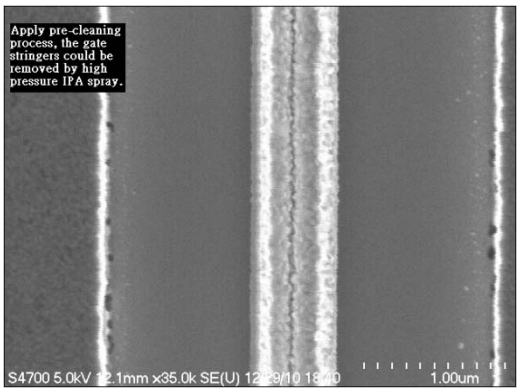
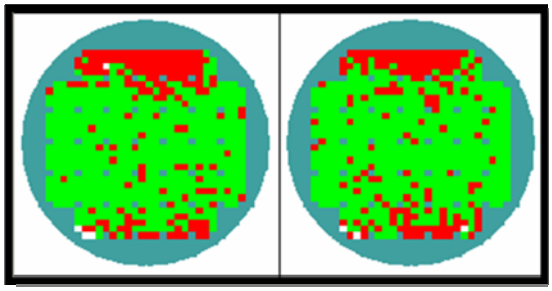
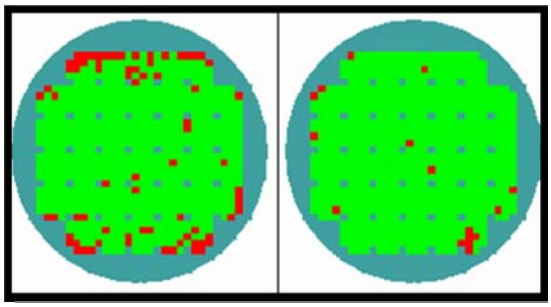


Figure 5, The SEM picture of the gate by using new lift-off process



(a)



(b)

Figure 6, (a) The yield mapping of wafer processed by traditional lift-off process. (b) The yield mapping of wafer processed by new lift-off process.