TSV Process Development

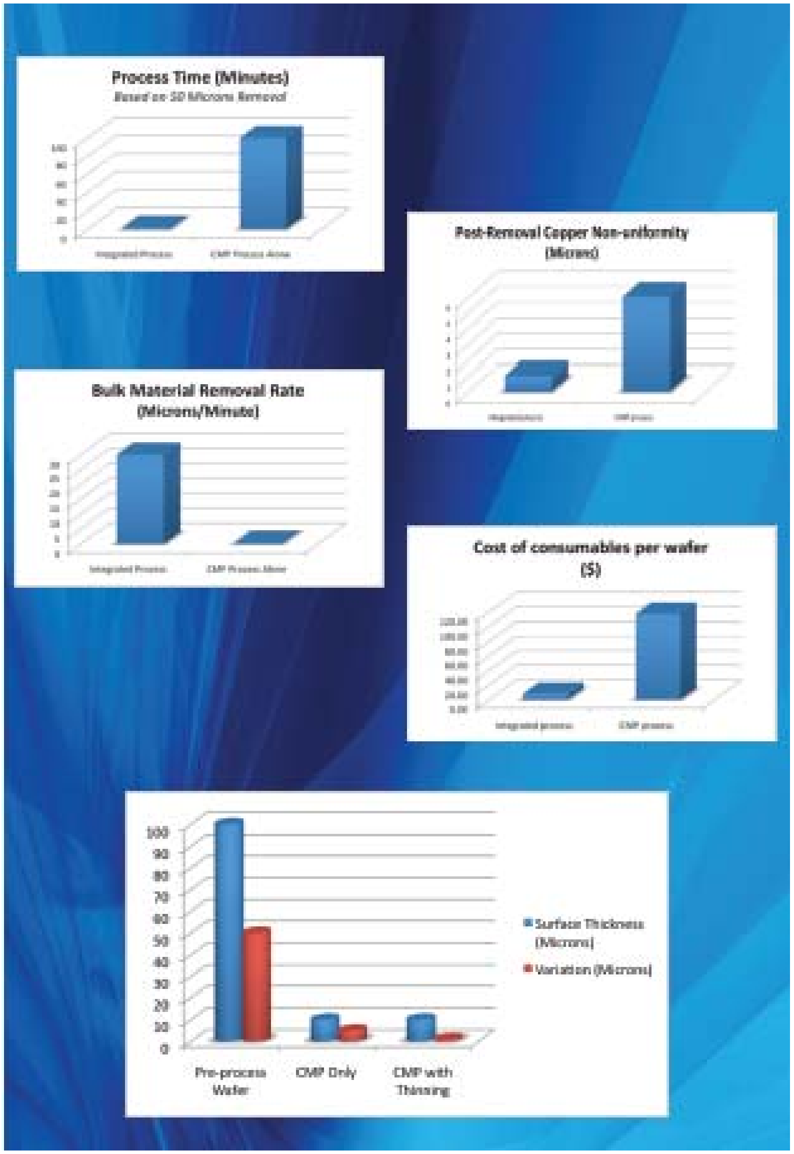
Sequence for Improved TSV Processing

Industry Problem
Conventional TSV planarization has depended entirely on CMP for both overburden removal and planarization causing significant undesirable trade-offs such as:

- High process cost - relatively low material removal rates and associated low process throughput, and the high cost of slurry consumption based on slurry cost and long process times.
- High non-uniformity of material removal inherent with CMP, which leads to variation and/or loss of either the metal or substrate thicknesses, or both.

Axus Solution
Axus Technology has developed specialized process conditions and consumables that enable substantial improvements in TSV planarization results based on a combination of advanced thinning methods and optimized CMP processes. These processes typically consist of three primary process steps.

- Thinning, which itself may be a single- or dual-stage process
- CMP to remove the remaining metal overburden and improve the final surface finish from a ground surface to a polished surface
- Post-CMP cleaning to establish a particle- and corrosion-free surface, enabling suitable post-planarization processes, including wafer-scale bonding.



Dual Layer Transfer Process

Dual Layer Transfer Process for Silicon-on-Sapphire MOEMS Device

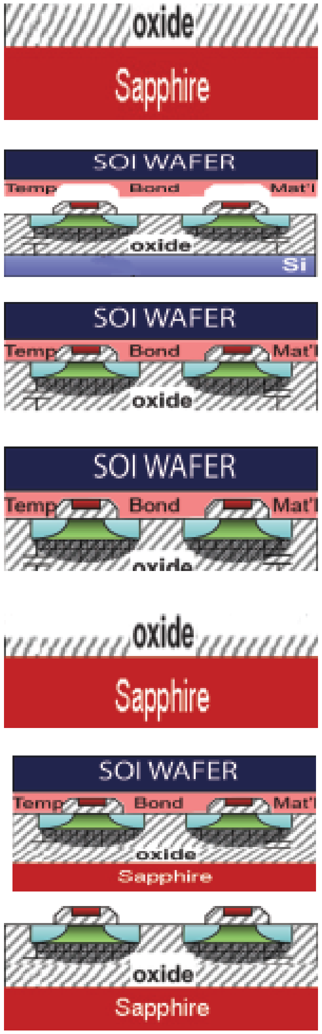
Industry Problem

New applications are evolving for advanced optoelectronic devices which require integrated processing and bonding of multiple substrates of dissimilar properties, including substrate material, thickness, electrical and optical properties.

Axus Solution

As an example of possible solutions, Axus Technology has developed a process that incorporates a thin-silicon-based opto-electronic device fabricated on a traditional silicon substrate, which is then permanently bonded to a transparent sapphire substrate for device packaging onto a rigid, transparent substrate with suitable optical and mechanical properties. This application combines multiple CMP steps, advanced wafer thinning processes, and both temporary and permanent bonding processes in order to achieve a thin optoelectronic device wafer permanently bonded to a transparent substrate.

Process Steps



Coat sapphire wafers with 1 micron PECVD oxide

Temporary bond SOI wafer to handle wafer

Thin bulk Si on SOI wafers and etch residual silicon with TMAH chemistry, stop on oxide

CMP oxide layer, target 0.25 µm removal

CMP oxide layer on sapphire wafers, target 0.25 µm removal, post-CMP clean

Permanent bond SOI wafer to sapphire wafer

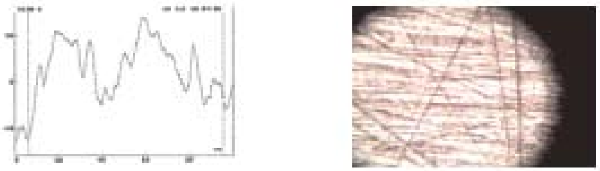
Remove temp bond wafer

Novel Materials Processing

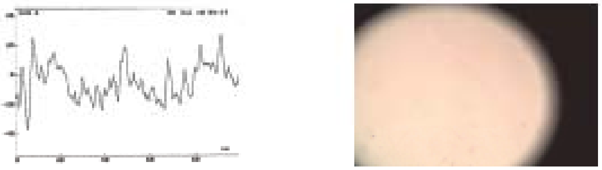
CMP Applications for Novel Materials

Industry Problem
Many new device structures including alternative substrate materials, particularly sapphire and III-V materials such as silicon germanium, gallium nitride, etc., and metals encompassing a wide range of materials, are currently being developed. Processes for such materials often benefit from CMP's proven advantages of planarization and surface quality management, however, no established process specifications typically exist for these relatively novel materials.

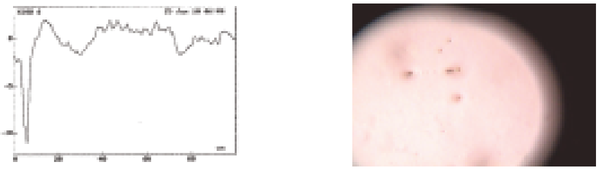
Axus Solution
Axus Technology has developed and demonstrated viable CMP processes for a number of such materials and applications. The example shown here is Kovar.
Kovar is an iron-nickel-cobalt alloy with a CTE similar to that of borosilicate glass, which makes it suitable for use in sealing device cavities in MEMS-type structures. A CMP process has been successfully demonstrated for Kovar wafer processing. Multiple candidate slurry formulations were identified, tested and characterized based on their chemical and abrasive properties. Relevant process results are summarized and compared below.



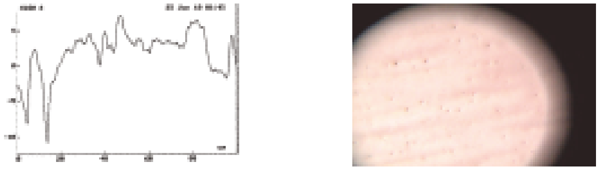
Pre-processing scan RA - >900A -- Surface showing very rough scratched cross hatching patterns.



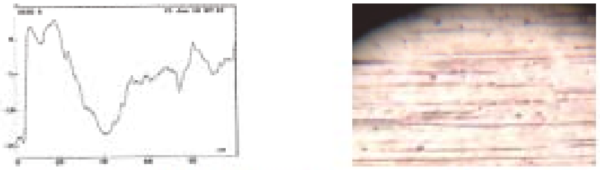
Post-process using Slurry 1 - Post CMP Roughness = 93A Ra, Removal Rate - 6.6 kA /min.
Surface showing much improved finish, high removal rate, good surface quality.



Post-process using Slurry 2 - Post CMP Roughness = 121A Ra, Removal Rate - 4.0 kA /min.
Surface showing some improvement, heavy pitting caused by the slurry.



Post-process using Slurry 3 - Post CMP Roughness = 220A Ra, Removal Rate - 0.5 kA /min.
Surface showing limited improvement, extremely low removal rate and signs of pitting caused by the slurry.



Post-process using Slurry 4 - Post CMP Roughness = 335A Ra, Removal Rate - 3.3 kA /min.
Surface showing limited improvement, low removal rate and signs of pitting caused by the slurry.