Advanced WLP Resist Stripping:

Jim Cullen[1], Wai Mun Lee[2]
[1] DuPont EKC Technology Ltd. East Kilbride, G74 4QL, UK jcullen@ekctech.com
[2] DuPont EKC Technology Inc.,2520 Barrington Ct.,Hayward CA 94545-133

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Abstract
This paper outlines the advances made by EKC in developing a solution for WLP resist stripping based on the globally established HDA® technology. HDA® technology has been expanded into WLP to give a solution that out performs traditional Solvent/TMAH blends.

Introduction
As the package I/O count and bump density on IC's continually increases it follows that the bump pitch , and line space/width must decrease. Consequently the criteria for photoresists in WLP bump formation have become increasingly demanding. Photospeed, resolution, resistance to plating solutions and resist strippability are important criteria for resist selection. Napthoquinone diazide (NQD) positive-tone resists, are predominantly used for gold bumping at thicknesses below 50µm. These resists are relatively easy to strip with organic solvents but are unsuitable for resist thicknesses of 50-120µm. Acrylic negative tone resists fulfil the majority of the criteria for these thicknesses but have been difficult to strip due to 3D cross-linking, high temperature treatment and reaction with plating solutions. Commercially available resist stripping formulations are predominantly DMSO or NMP based and incorporate TMAH. These strippers exhibit problems in delivering complete and consistent removal of the resists used in electroplated solder bumping. Residual polymer around the bottom of the bumps and visibly undetectable residue that masks UBM etching, are two common manifestations of incomplete stripping. Short bath life is a universal problem. Compatibility of the stripper with a multitude of UBM's and bump compositions is essential and critical. High Lead content bumps are particularly sensitive to chemical attack. This paper will discuss a new approach for the development of suitable strippers for WLP Electroplating bumping applications.

Current Resist Stripping Technology
Current organic solvent based stripping solutions have difficulty removing thick, negative tone, acrylic resists as shown in Figure 1. These simple formulations lack the necessary chemical activity to break down thick, heavily crosslinked 3D polymer networks, even at elevated temperature and prolonged times.

Removal of thick resist is difficult for traditional solvent based strippers especially after electroplating

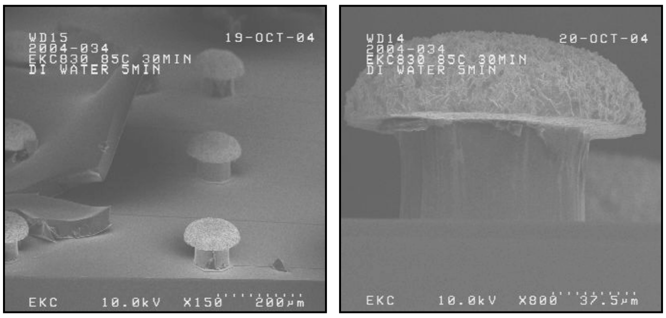


Fig 1. Incomplete resist removal with current solvent based strippers.

Formulation Development
A series of screening experiments identified three components with a strong influence of resist stripping. A set of nine multi-component formulations, based on these components was generated by a statistical mixture DOE, over the formulation composition shown in Figure 2.

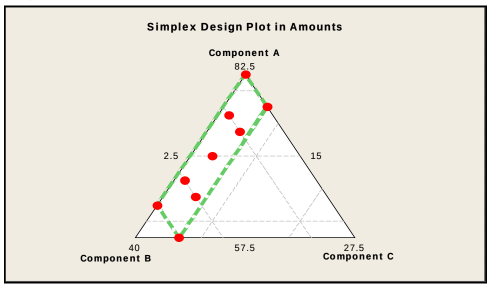


Fig 2. Simplex Design from DOE mixture

This matrix was extensively tested to determine the optimum formulation, minimising UBM and solder etch but retaining fast and efficient resist removal.
The resultant formulation was EKC108™.

Results
EKC108™ with various resists, UBM's and bump compositions.

Resist: JSR 151N,(acrylic negative tone resist)
Bump: Lead Free

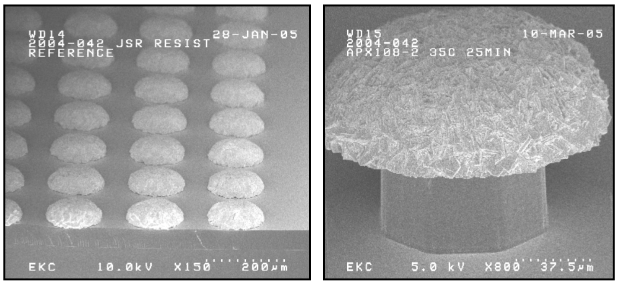


Fig 3. Complete removal with EKC108™, 25min, 35° C

Resist: AZ4562 (positive resist). Bump: Eutectic PbSn

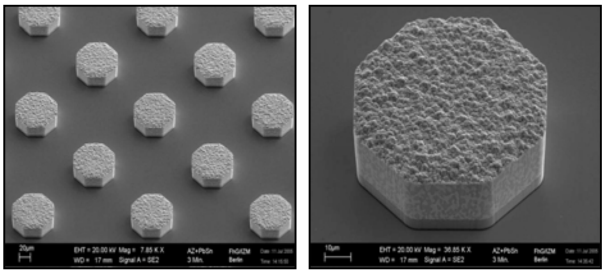


Fig 4. Complete removal with EKC108™, 3mins., 50 °C.

Resist: JSR124N(negative tone resist). Bump:Eutectic PbSn

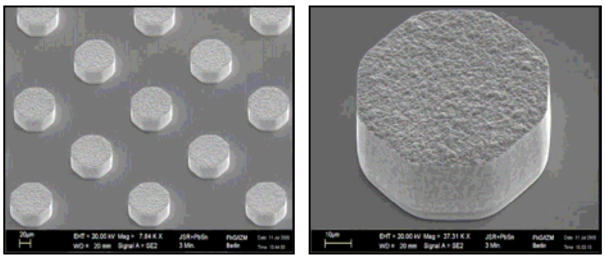


Fig 5. Complete removal with EKC108™, 3 mins., 50 °C.

Mechanisms

Table 1 Photoresist stripping mechanisms for IC manufacturing.

Dry Process	Wet Process	Mechanism
O2 Plasma	H2O2/H2SO4 (NH4) 2S2O8/H2SO4 Fuming Nitric Acid	Oxidation
SCCO2	Solvent Stripper Alkaline Developer	Dissolution
H2 Plasma	Hydrazine/ Hydroxylamine	Reduction

Due to the unique properties of HDA® a dissolution mechanism is proposed whereby disproportionation, dissociation and ionisation combine to remove the resist.

For thick acrylic negative tone resists this mechanism is particularly effective for the cross-linked acrylic functional groups.

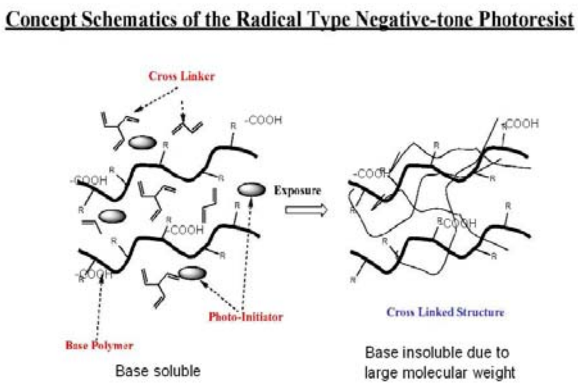
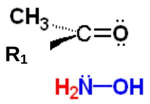


Fig 6. Cross linking of JSR negative tone resist

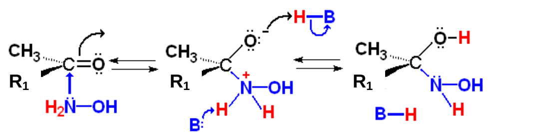
The resist is cross-linked after exposure and becomes base insoluble. A principle cleaning mechanism in EKC108™ technology is based on the chemical reaction to break down cross linked polymers and form more soluble oximes.

Technology: Aprotic Solvent - DMSO, Acid/Base – Water, Reactive – Hydroxylamine

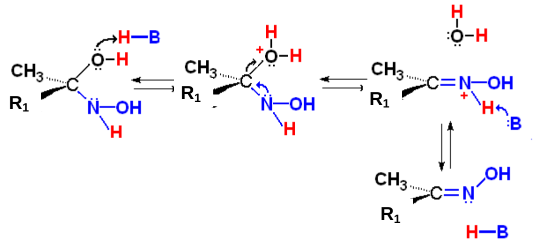


Oxime Formation

The reaction begins with nucleophilic addition to the carbonyl functional group.



The addition product is then protonated and dehydrated.



The result is an increased solubility of the product (oxime) formed.

The chemical activity imparted to EKC108™ through HDA® technology greatly improves the ability of the formulation to remove very thick, 50-100µm resists at far lower temperatures and shorter times than conventional offerings. Importantly, HDA® technology also extends the functionality of EKC108™ to include Dry Film Resists

Conclusion

HDA® technology for the removal of WLP resists has been discussed. This technology can be used effectively for stripping a variety of resists on different substrates with varying UBM and bump compositions.

Acknowledgements

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References

Katsuji Doki , “Advances in thick photoresists for flip-chip bumping,“Solid State Technology August 2005, p47.

JSR, APiA, Semicon West

Wai Mun Lee, “A proven sub-micron Photoresist Stripper solution for Post Metal and Via Hole processes”, 1996.

Dr. Richard Pendarvis, CFCC Organic Chemistry 2005

Footnote

HDA(r) - Registered Trademark of EKC Technology, Inc.
TMAH - Tetramethylammonium hydroxide
WLP - Wafer level packaging
DMSO - Dimethylsulphoxide
NMP - N-Methylpyrrolidone