# Counterfeit Prevention of Microelectronics through Covert Anti-Tamper Microcapsules

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## Introduction and Broader Impact

Microelectronics counterfeiting is:

- Estimated to cost the world semiconductor industry $7.5 billion annually. [1]
- Considered to threaten the US military through infiltration into key electronics systems.
- Generally performed by sanding off the part numbers of old electronics components and/or resurfacing the parts prior to remarking with falsified information.

The development of improved anti-counterfeiting technology for microelectronics will:

- Result in more reliable consumer electronics.
- Aid in national security.

## Objective

**Create a simple and effective means to mark authentic microelectronics with upconverting nanoparticle-loaded microcapsules which will break and stain the part upon sanding.**

- The stain will only appear under near infrared (NIR) light, adding another layer of security.

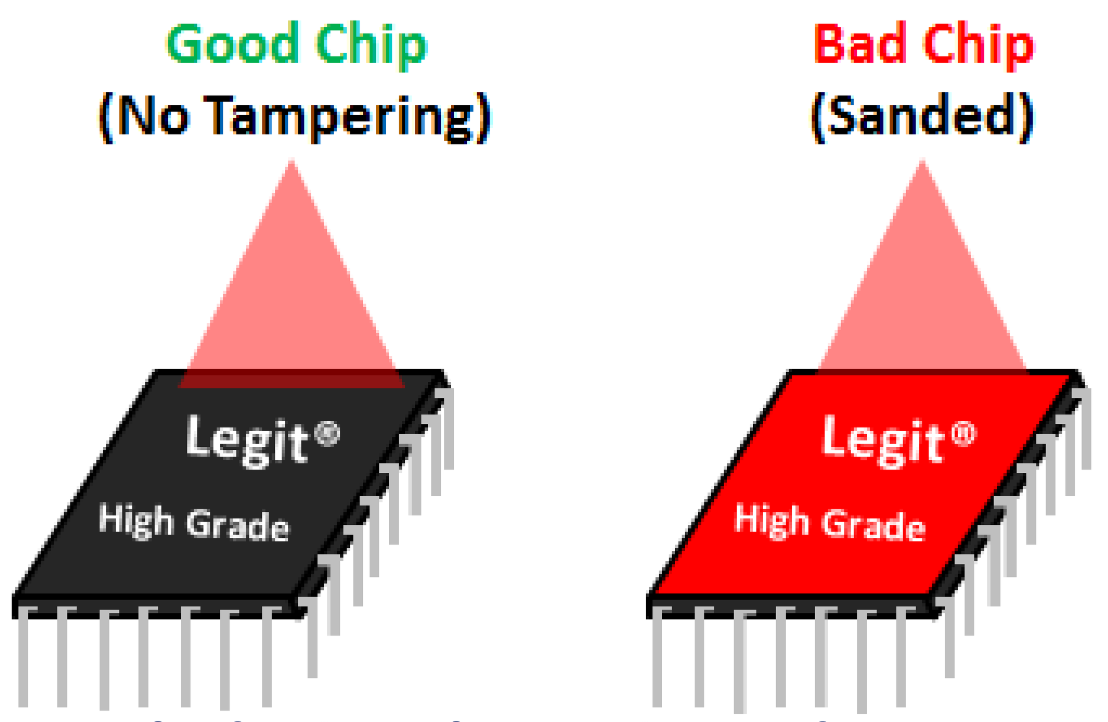


Figure 1. Marked Microelectronics Under NIR Inspection.

## Procedure

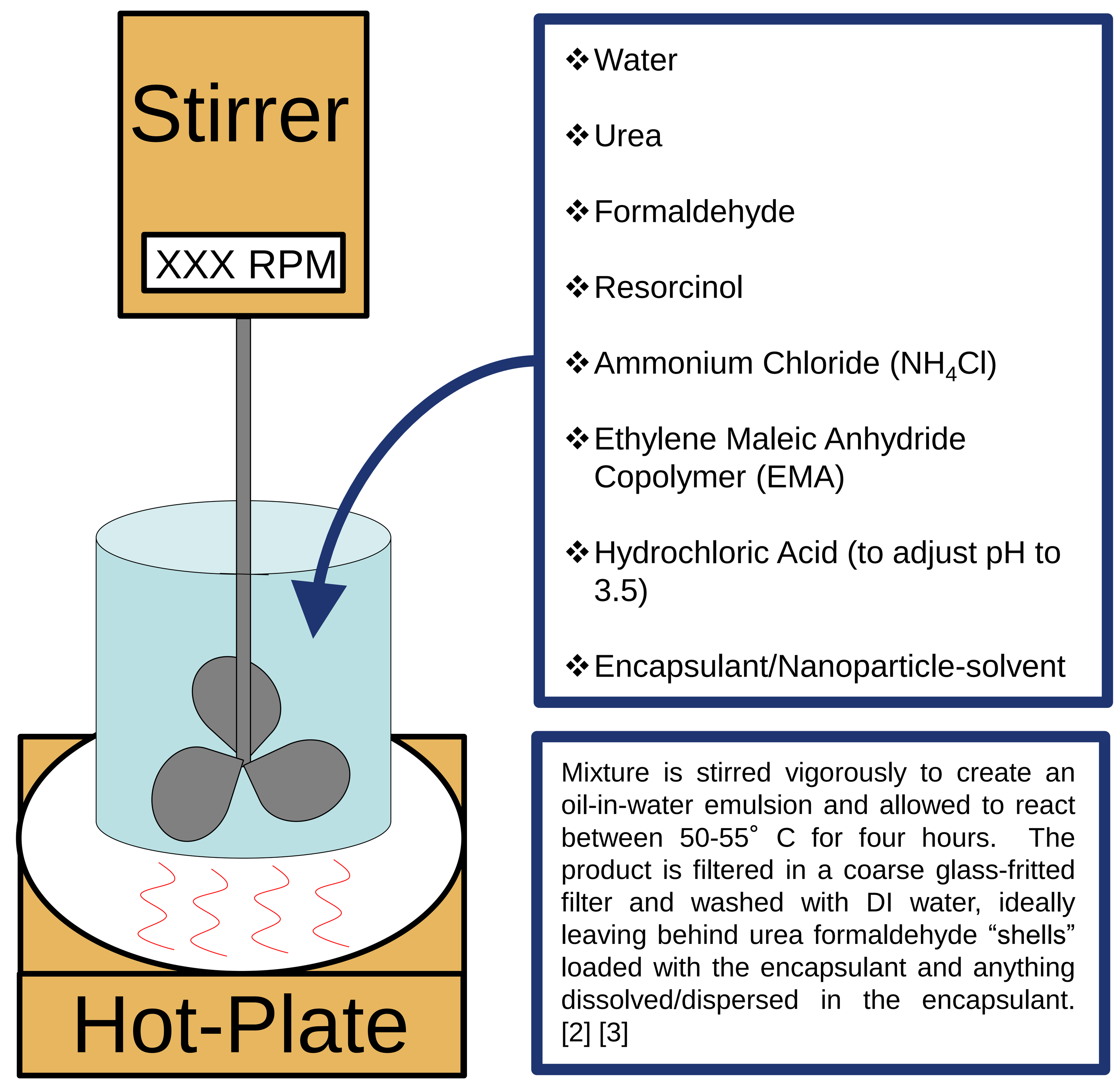


Figure 2. Schematic Procedure Representation.

Table I. Experimental Variables.

| Test Batch | Water (mL) | Urea (g) | Formal-dehyde (mL) | Resorc-inol (g) | $NH_4Cl$ (g) | EMA (g) | Encap-sulant (10mL) | RPM | Temp (°C) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 41 | 1.16 | 2.0 | 0.083 | 0.083 | 0.83 | Toluene | Stir Bar | N/A |
| 2 | 41 | 1.16 | 2.0 | 0.083 | 0.083 | 0.83 | Toluene | Stir Bar | 50-55 |
| 3 | 41 | 1.16 | 2.0 | 0.083 | 0.083 | 0.83 | Oleic Acid | Stir Bar | 50-55 |
| 4 | 83+ | 1.16 | 2.0 | 0.083 | 0.083 | 0.41 | Olive Oil | 750 | 50-55 |
| 5 | 111 | 1.16 | 2.0 | 0.083 | 0.083 | 0.41 | DCPD | 500 | 50-55 |

## Results and Conclusions

- Test Batches 1-4 showed no evidence of microcapsule formation, but Test Batch 5 contained small numbers of broken microcapsules, suggesting dicylopentadiene (DCPD) as the only viable encapsulant tested.

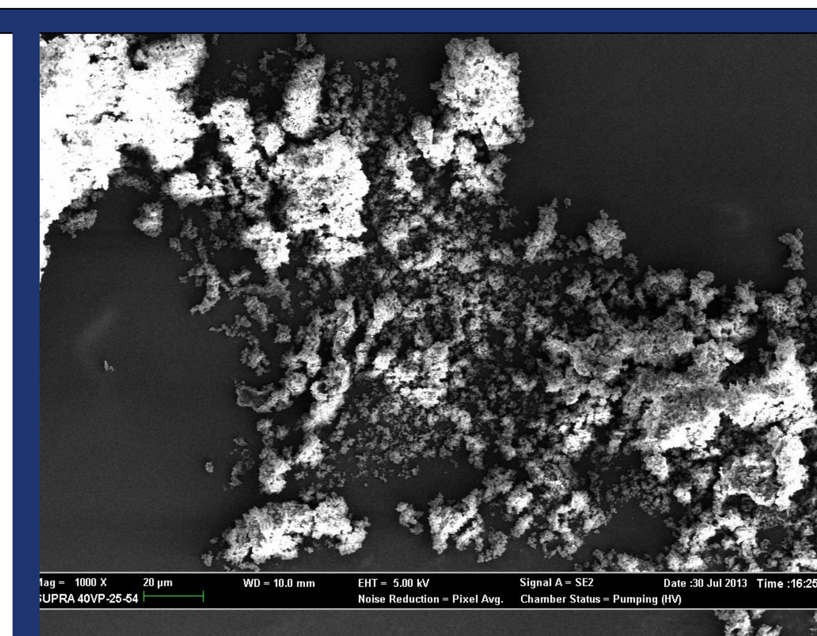

Figure 3. Test Batch 2 SEM Image.

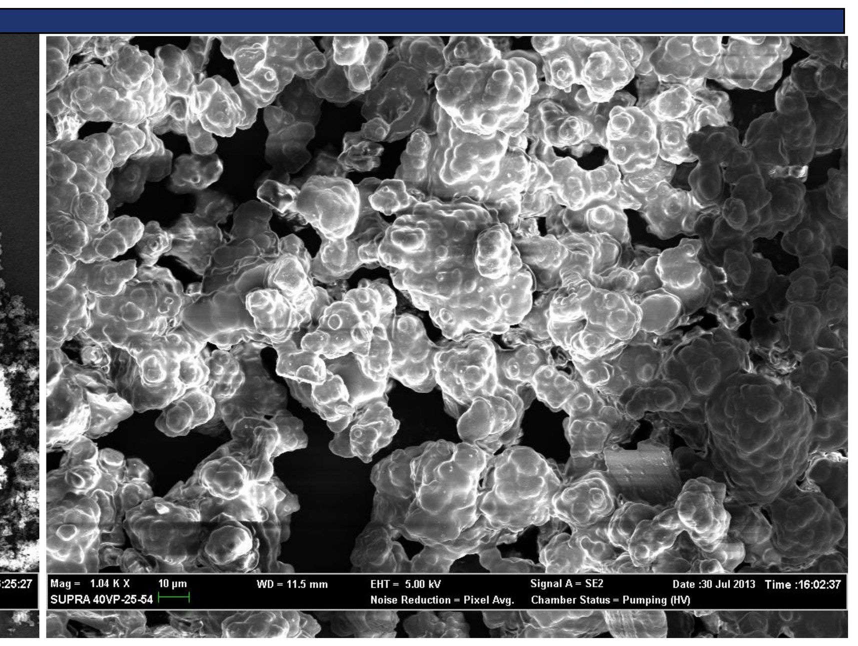

Figure 4. Test Batch 4 SEM Image.

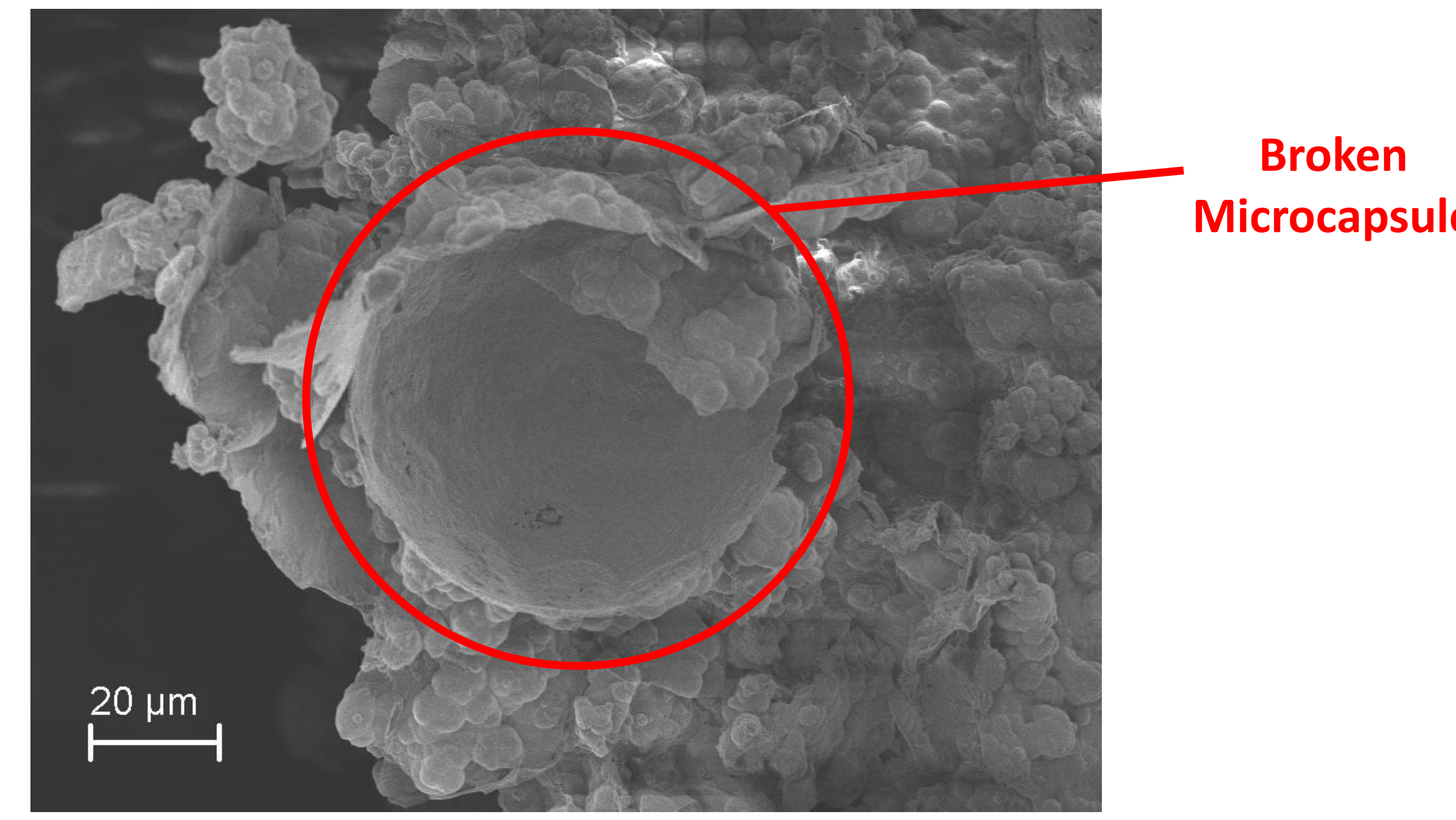


Figure 5. Test Batch 5 SEM Image.

- The upconverting nanoparticles are not soluble in DCPD, making the encapsulation of nanoparticles by the *in situ* urea formaldehyde encapsulation process difficult.

## Future Work

- The process of *in situ* urea formaldehyde micro-encapsulation must be perfected or alternative encapsulation methods must be developed.
- Microencapsulated upconverting nanoparticles must be applied to real microelectronics and their effectiveness characterized.

## References

[1] Koushanfar, F., Fazzari, S., McCants, C., Bryson, W., Sale, M., Song, P., & Potkonjak, M. (2012, June). *Can eda combat the rise of electronic counterfeiting*. 49th annual design automation conference dac '12, San Fransisco, CA.

[2] Brown, E. N., Kessler, M. R., Sottos, N. R., & White, S. R. (2003). In situ poly(urea_formaldehyde) microencapsulation of dicyclopentadiene. *Journal of Microencapsulation*, *20*(6), 719-730.

[2] White, S. R., Sottos, N. R., Geubelle, P. H., Moore, J. S., Kessler, M. R., Sriram, S. R., Brown, E. N., & Viswanathan, S. (2001). Autonomic healing of polymer composites. *Nature*, *409* (6822), 794-797.

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