Covert Printing of Near IR to Near IR Upconverting Nanoparticle Ink for Integrated Circuit Anti- Counterfeiting Techniques, and Development of an Effective Detection Method

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Abstract:

This report details the development of near IR (NIR) to NIR upconverting nanoparticle inks, as well as the formulation of an effective and fast detection method for the purpose of anti-counterfeiting. A security ink containing lanthanide doped upconverting nanoparticles was synthesized. A tabletop apparatus was designed to collect the 800nm emission from the ink when excited with a 980nm light while effectively filtering the 980nm excitation wavelength. This anti-counterfeiting technique could be implemented in microcircuit distribution in order to prevent counterfeiting by burying the ink inside of legitimate chips.

Introduction:

- The development of a covert- to –covert anti- counterfeiting method using NIR to NIR upconverting nanoparticle inks is an essential step in the fight to thwart counterfeiters [Fig. 10].
- Three procedures were done to determine the efficacy of this new method of anti- counterfeiting.
    - The first was to determine if the 800nm emission from the inks was strong enough to make a covert – to – covert detection of a QR code.
    - The second was to test epoxy resins from microcircuits in order to find out whether or not transmission in the near – IR range was possible.
    - The third was to design a detector and formulate a basic method for detecting QR codes with only the 800nm emission.

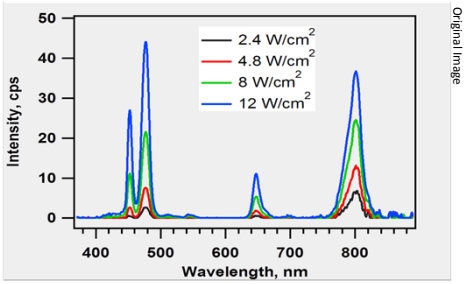

Fig. 1: Emission Spectrum of UCNP blue ink

Fig. 2: QR code under visible light

Fig. 3: 800nm invisible emission

800nm Emission

1. Emission spectrum was collected [Fig. 1].
2. QR code was printed with upconverting nanoparticle inks [Fig. 2,3].
3. Excitation of QR code by 980 nm laser at 1.7 watts
4. QR code imaged using Microsoft VX-6000 with IR cutoff filter removed.
5. Excitation wavelength removed with 800nm Bandpass filter
6. Images analyzed to determine readability and limiting factors and QR code readability

Epoxy Testing

1. Epoxy acquired from various circuit boards for variety.
2. Transmission spectra at variable thicknesses were collected from one chip [Fig. 4].
3. Epoxy was removed from one chip in order to test transmission [Fig. 5-8].

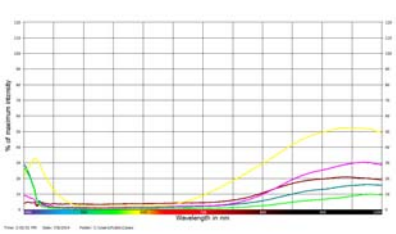
Fig.4: Transmission of IC epoxy


Fig. 5: IC package

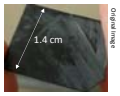

Fig. 6: Epoxy removed from IC

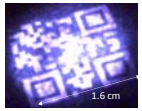

Fig. 7: Tested QR code

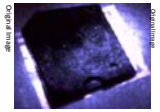
Fig. 8: Epoxy over QR code

Laser/Detector Apparatus Design

1. VX-6000 camera IR filter removed
2. 800nm Bandpass filter from Edmund Optics
3. Laser acquired from WarnLaser.com
4. Raspberry Pi for smartphone-laser interface
5. Smartphone
6. Current setup [Fig. 9].

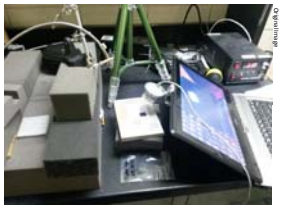
Fig. 9: Current reader setup

Concept schematic below [Fig. 10].

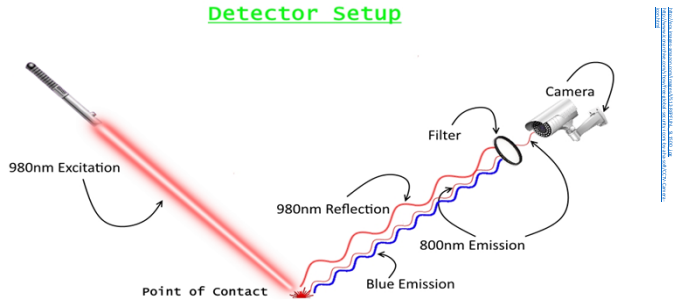

Fig. 10. Concept schematic for NIR to NIR detection apparatus

Design Parameters:

1. Must be controlled by smartphone app, being coded by Julian Brackins
2. Must be small, portable
3. Must not only detect 800nm emission, but also green, blue, red QR codes
4. Must withstand heat that laser gives after hours of use

Results / Expected Results:

1. 800nm emission has adequate intensity for detection, even at low excitation power densities.


Fig. 11: 800nm Emission QR code

Fig. 12: QR code after image manipulations

2. Some, not all (Transmission of failed epoxy [Fig. 13]) , epoxy is reasonably transmissive in the near infrared, further testing required to characterize which epoxies can be used.

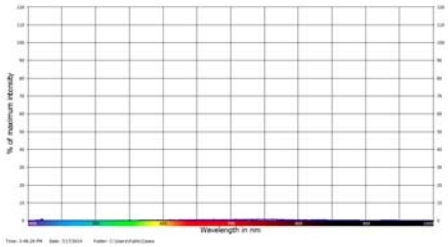
Fig. 13: Transmission of Epoxy from Figure 8

3. Detector apparatus, as currently designed, can effectively detect and read QR codes in the 800nm range, and in the future should be able to detect colored QR codes.

Conclusion:

The development of an NIR to NIR security feature with a detection apparatus is an essential step in preventing counterfeiting of microelectronics. If the epoxy can be characterized and optimized for this anti- counterfeiting method, the ink could be printed within the packaging of any integrated circuit. The near-IR transmission would be essential for this task. The detector apparatus in development could be implemented at any point in the production line. The portability of the device is essential for its implementation. It will be controlled by any smartphone with the app.

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