

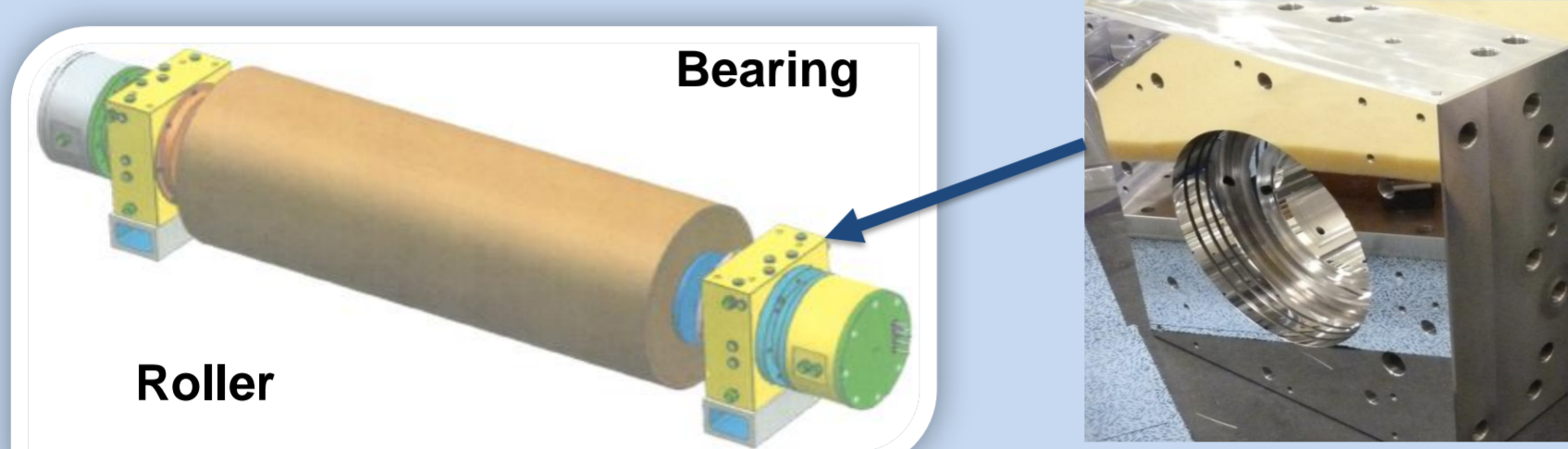
## Optical Quality Wear Resistant and Diamond Turnable Coatings for Aluminium Rollers and Hydrostatic Bearings

Peter Xia Email: p.xia@cranfield.ac.uk

Supervisors: Dr Sue Impey & Dr Heather Almond

### Background information

Exciting research and development is underway in large scale (1.4m wide), reel to reel (R2R) manufacturing techniques for the production of plastic and electronic parts.

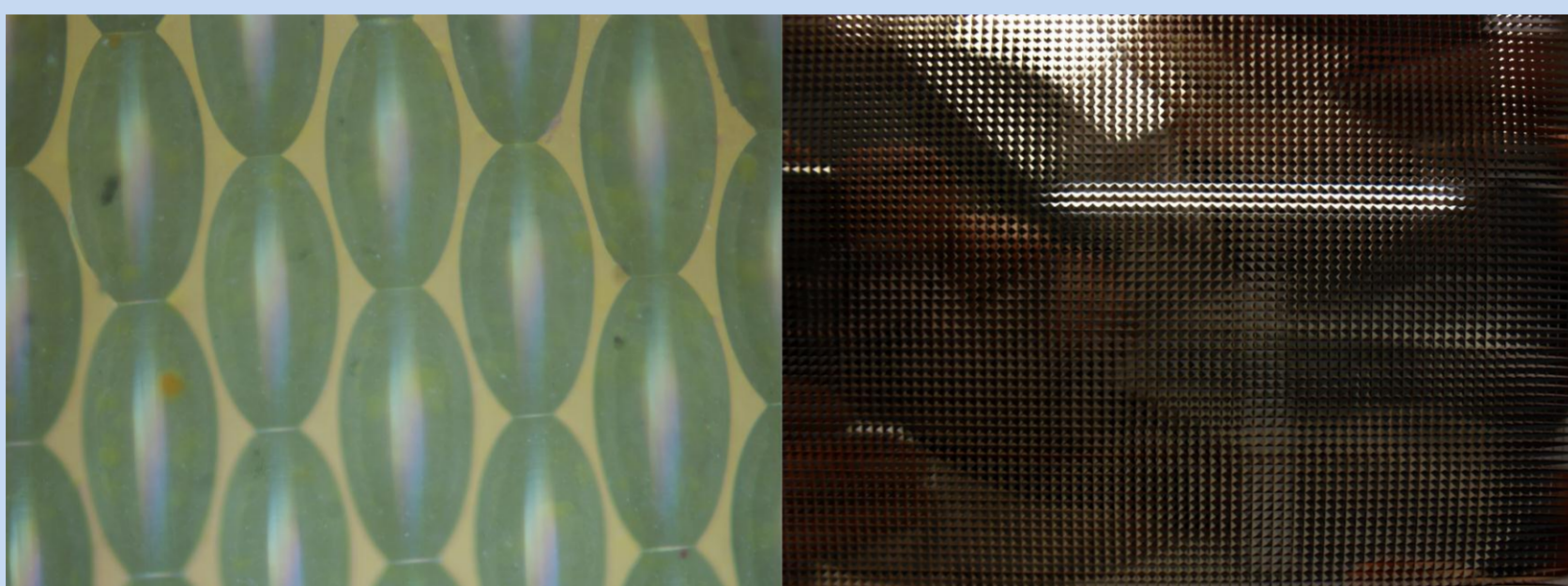


Reel-to-Reel roller and bearing

Images: Ultra Precision Institute

R2R involves the application of coatings, printing, or performing replication processes starting with a roll of a flexible material and re-reeling after the process to create an output roll.

Structured rollers and hydrostatic bearings are production machine components used in the R2R manufacturing system. They are typically made of aluminium and steel and are subsequently diamond machined. Bearing surfaces require an ultra-smooth finish and the rollers require additional micro-features which will form the structured surface for replication

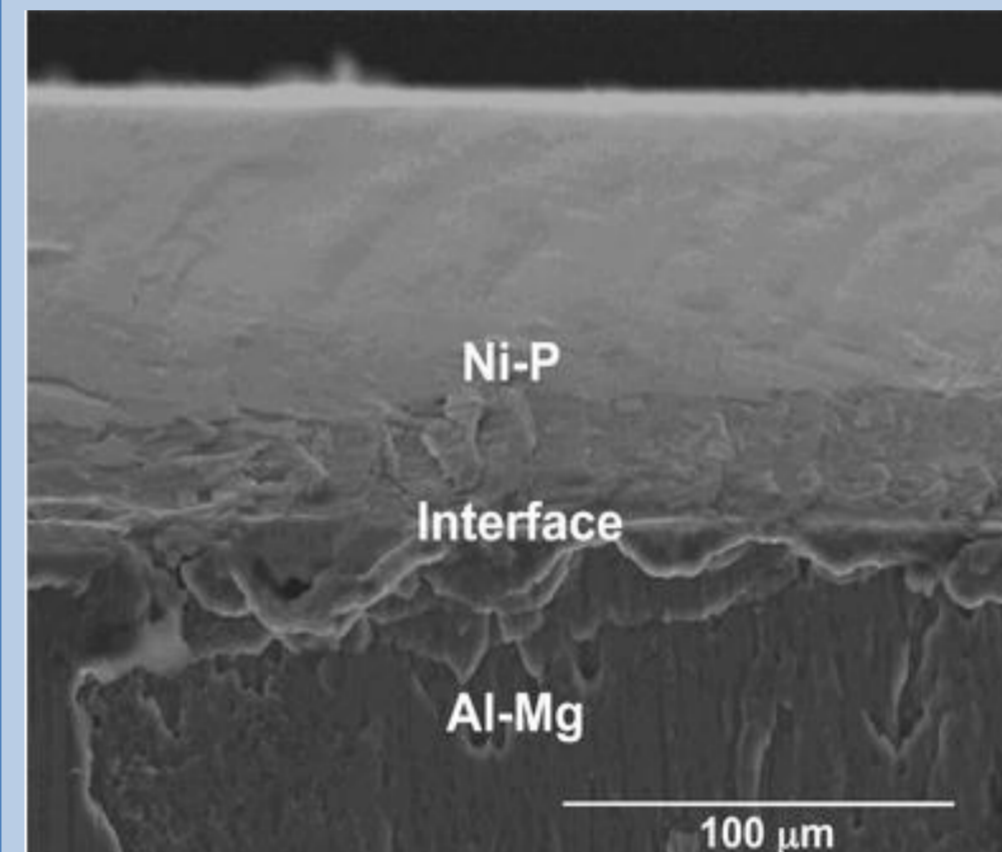


Examples of diamond turned structured surface on rollers (left: Micro lens array; Right: Pyramid structure. Images UPS<sup>2</sup>)

### Autocatalytic (Electroless) Nickel Coating

#### ✓ Advantages

- ✓ Conformal coatings.
- ✓ Large throwing power compared to electroplating.
- ✓ Little or no excess deposit at edges and high points.
- ✓ Excellent physical and chemical properties including wear and hardness.
- ✓ Reduced hydrogen embrittlement.
- ✓ Ability to coat surfaces which would be difficult or impossible by electroplating.
- ✓ Diamond turnable with high (12-14 wt%) phosphorous content.



SEM cross section of Al hard disk  
Image: W. Luesaiwong & R. Marcus



Fresnel Lens on copper roller  
Image: UPS<sup>2</sup>

#### × Disadvantages

- × High cost for this application (high quality, low volume product).
- × 20% average defect rate via existing processing route.
- × Plating procedure variation and working environment can greatly affect the coating outcome.
- × Potential health and safety legislation.

### The Project

To enhance the bearing and roller wear resistance, and enable reworking and reduce costs for the structured rollers the deposition of a diamond turnable coating on the substrates is required .

#### Coating and plating facility requirements:

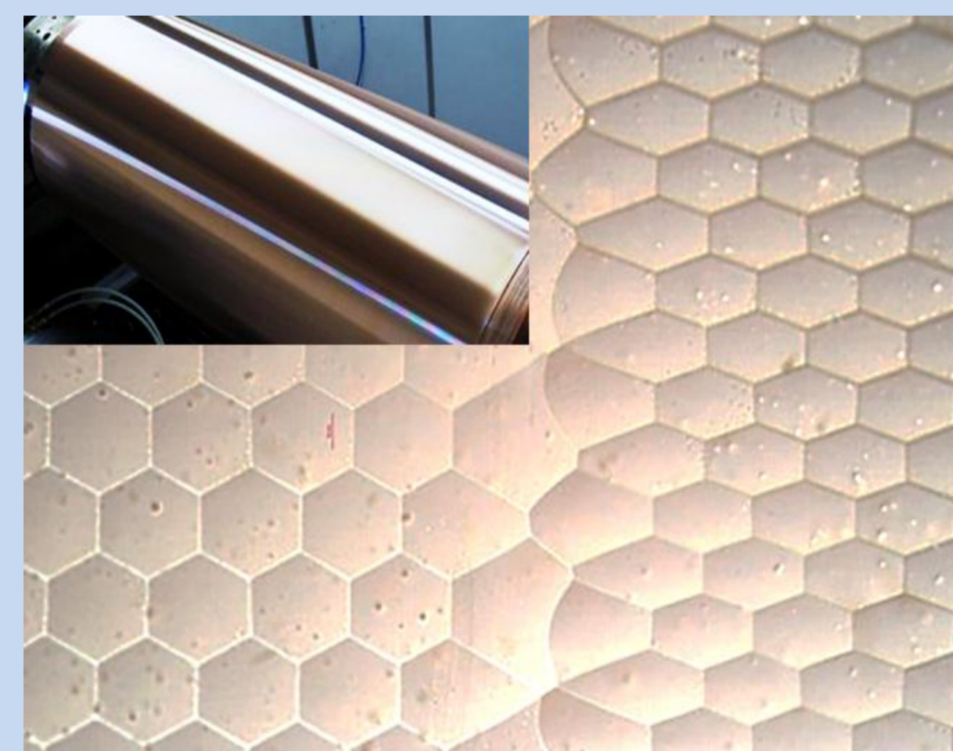
- *Target coating:* Deposition thickness: >300μm for diamond turned micro features; Coating quality: defect free and acceptable pore size/percentage/concentration); Coating performance: wear resistant; low diamond turning tool wear rate.
- *Post processing:* Characterisation of coating surface; On-line defect assessment.
- *Facility:* Equipment/mechanical needs: capable of plating rollers 1.4m long and over 200kg; Plating process control: bath chemistry composition, contamination control.

#### Aims and Objectives

This project is to recommend or establish a UK capability for producing optical quality, wear resistant, diamond turnable coatings suitable for application to hydrostatic bearings and structured rollers.

1. Benchmark "optical quality finish" for diamond turnable coatings.
2. Identify the potential coatings for deposition and the advantages.
3. Identify descriptors for specifications (terminology).
4. Explore and trial alternative processing routes for plating.
5. Guidelines for assessing quality of diamond turnable coatings.
6. Recommend suitable providers, partners, modifications and/or a process route.

### Summary



Hexagon micro-lens array  
structured surface on copper  
roller, Image: UPS<sup>2</sup>



Visible pitting on diamond turned spindle  
sample with 75μm electroless nickel  
coating, Image: Poeton

#### Project progress

- Bath compositions have been identified and chemicals obtained.
- Laboratory size test bath set-up.
- Alternative coating (titanium copper nitride) has been identified as an alternative diamond turnable coating and not subject to the REACH SVHC list 2013.
- Industrial confirmation regarding pre surface treatment for Ni-P plating.

#### Current work and next 3 month work plan

- In-house pre surface treatment, and surface characterisation to be conducted
- Design suitable test piece for plating assessment
- Compare coatings from plating suppliers as available
- Identify descriptors for specifying plating parameters, coating. quality, defects etc.
- Explore opportunities with industrial contacts