The Analysis of WC surfaces and Diamond Thin Films by Laser-Acoustic Surface Waves

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Presentation Outline

Diamond Coating
- Production flow
- Process and equipment
- Microstructure

Quality control by E-Modulus
- LAWave® equipment
- Measurement quantities

Results
- Overview LAWave® spectra
- Ground versus ground & etched
- Diamond coatings
Diamond Coating – Production Flow

Incoming Material
- Co content
- Roughness
- standard or micro grain

Pre-Treatment
- etching
- additional treatment

Coating Process
- standard diamond
- smooth diamond

QC

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Diamond Coating – Equipment & Process
Diamond Coating – Micro vs. Standard Grain Substrate
Diamond Coating – Smooth vs. Standard Grain Film
E-Modulus as Sensitive Quantity to Control Quality

E-modulus for some bulk and coating materials

Highest modulus
diamond (E = 1147 GPa)

Lowest modulus
polymers

Coatings
Considerable variation depending on deposition parameters

→ Quality Control
Laser-Acoustics LAWave – Equipment
Laser-Acoustics LAWave® – Software Interface
Laser-Acoustics LAWave® – Characteristics

- Non-destructive measurement
- Fast measurement cycle
  → < 2 min
- Accurate measurement cycle
  → $\Delta c/c = 2 \times 10^{-4}$
- Easy-to-use equipment
  → handling, software
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Results – Roughness of Ground and Etched Material

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Results – Overview LAWave® Spectra

- Smooth diamond
- Std. diamond
- advanced
- ground
- etched

Phase velocity [m/s] vs. Frequency [MHz]
Results – Ground versus Ground & Etched Material (1)
Results – Ground versus Ground & Etched Material (2)

Substrate E-modulus (GPa)

- K68 standard 6%Co
- CQ22 micro 10%Co
- PL2 standard 6%Co
- K313 micro 6%Co
- HTi10 standard 6%Co
- Micro100 micro 10%Co
- H21 standard 6%Co

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Results – Process Steps (1)

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E-Modulus (GPa)

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<tr>
<th>Condition</th>
<th>Micro 10%Co</th>
<th>Micro 6%Co</th>
<th>Std 6%Co</th>
<th>Micro 10%Co</th>
<th>Micro 6%Co</th>
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Results – Process Steps (2)

- **Micro 10% Co**
- **Micro 6% Co**
- **Standard 6% Co**

<table>
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<th>Process Step</th>
<th>E-Modulus (GPa)</th>
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Results – Example Process Variations

E-Modulus (GPa)

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<th>Process</th>
<th>Value</th>
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<tr>
<td>Std 6% Co Standard Etching</td>
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<td>Std 6% Co Additional Treatment</td>
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<td>Std 6% Co Standard Etching</td>
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<td>Std 6% Co Additional Treatment</td>
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Summary / Conclusions

- LAWave® as quality control and film development tool
  - Co% change from 5% ..10% very sensitively detected → can control incoming material
  - Effective E-modulus change due to etching (Co depletion) very sensitively detected → can control material prepared for coating
  - Effective E-modulus change due to different diamond coatings very sensitively detected → can control coating quality
  - Tool also proved successful to support film development

- Diamond coatings
  - Smooth diamond coating yields an effective E-modulus of \((1123 \pm 22)\) GPa
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