Counterfeit Resilience of Optical Banknote Security Features based on **Micromirrors** with **Color-Shifting PVD Coatings**

**Multiplying Security and Complexity**
Company Profile:

- Subsidiary of technology company Giesecke & Devrient (Munich).
- Leading international manufacturer of banknote paper and security features.
- Central banks and government ministries from over 100 countries worldwide trust in the high quality of our products.
- A major supplier of paper for the Euro.

- ~1000 employees
- ~20,000 tons of banknote paper a year (20 billion banknotes)
- Foil production plant
- >15 million square meters annual foil production

⇒ Today one of the world’s technology leaders in foil-based high security elements.
Security Structures: Microstructures

Security Structures
Holograms

- **Optical Principle:** Diffraction
  - White light is split into spectral colors
  - Low intensity

- **Topography:**
  - Depth $< 1$ mm
  - Period $< 1$ µm

- **Origination:**
  - Dot Matrix, Laser Interference, E-Beam...

- **Embossing:**
  - Soft embossing, hard embossing, UV-casting
Security Features: Microstructures

**Micromirrors**

- **Optical Principle:** Reflection
  - White light reflection without diffraction
  - High intensity

- **Topography:**
  - Depth < 10 µm
  - Period < 10 µm

- **Embossing:**
  - UV-casting

- **Effects:** Achromatic 3D, flip and dynamic effects
Security Coatings
Aluminum

- **Optical Principle:**
  - white reflective coating
  - ~ 90 % reflectivity

- **Thickness:**
  - below 200 nm

- **Production:**
  - Vacuum coating machines
  - Wide boat evaporators
Color-Shifting Coating

- High brilliance of colors
- Color changes when tilted
- Three coating layers
- Optical principle: Interference

Production:

- Expensive vacuum coating machines
- Mastered only by few security companies

Thickness precision of dielectric layer: a few nanometers
## Combining Topography with Coating

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<td>Al</td>
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Matrix: Complexity & Security
RollingStar®: Micromirrors + Color Shift

Security

RollingStar = Micromirrors + Color Shift

Maximum Security = special origination + special embossing + very rare worldwide

- Color and dynamic effects attract attention
- Public will recognize if missing or bad quality
- Increase of security
Security Threads

- Incorporated multi-functionality including holograms, de-metallization, UV luminescence, machine-readable properties (magnetics, conductivity, ...).

- Widely recognized by the public, quick and easy authentication, up to 6 mm width.

- Extremely complex to produce to ensure protection against counterfeiting.

- Embedded authentication solutions with multi-level counterfeit protection.
Rolling Bar

RollingStar® Thread examples
Rolling Star® Thread examples

Rolling Cube
RollingStar® Thread examples

Crocodile

untitled view
tilted view
How can we increase security even more?

Increase in …
- Area
- Design options
- Atractivity
- Complexity

… by color-shifting transfer foil with …
- Holographic effects
- Dynamic micromirror effects
- Demetallization
What else can we do?

- Increase complexity
- Increase attractivity / attention

Combining all structures with all coatings!

Rolling Star Transfer Foil = Hologram + Micromirrors + Color Shift + Micromirrors
Technical Challenges

- Increased number of production steps
- Repeated demetallization
- Demetallization of thick optical layer
- Transfer foil technology

Hologram transfer foil
- 3 production steps
- 3 layers

Rolling Star transfer foil
- 8 production steps
- 8 layers
RollingStar® Transfer Foil Examples

Holographic effects
Micromirror effects
Aluminum areas
Color Shift

Maximum product complexity
Maximum attractivity level

→ Highest security level
RollingStar® Transfer Foil Examples
2016: Introduction of …GALAXY™
Visual effects when tilted:

- Dynamics
- 3D depth
- Color-shift

Immediate recognition due to the multiple eye-catching OVD effects.
- Security by complexity in combining micromirrors with holographic and color shift elements.
- High technological hurdle for counterfeiters.

Galaxy™: a quantum leap in optical effects
Production of Color-Shift Foil

Color-Shift

Color-Shift + Micromirrors
Challenges …

- Winding and rewinding
- Wrinkles and folds
- Electrostatics (in vacuum…)
- Pinholes
- Color is shifting ... away
- Layer thickness tolerance for color appearance: a few nanometers
- Quality inspection < 1,0 mm²
- Register
nevertheless …

- millions of squaremeters color-shift foil produced
- wide coating width
- numerous color-shift combinations
- we are happy to sell color-shift foils to the security market
- …and we still have some capacity
Thank you very much for your attention!
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