Willkommen
Welcome
Bienvenue

Strategic Focus Area
Advanced Manufacturing

DiPrintProtect - Digitally printed temporary protective films for application in the watch industry

Annual Review Meeting 2021

Empa
Materials Science and Technology

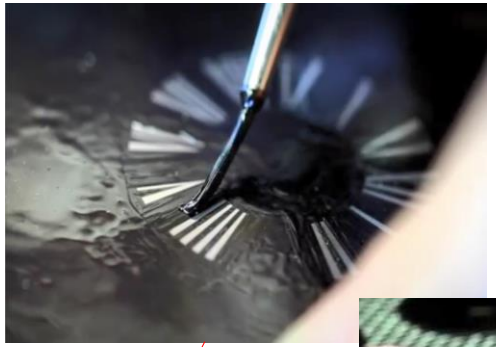
EPFL ETH zürich

Motivation

ASRH

RECHERCHE HORLOGERE COMMUNAUTAIRE

Association Suisse pour la Recherche Horlogère
Swiss Association for Horological Research



www.metalem.ch

A – Masking of selected areas for mechanical processing

B – Protection of finished watch parts for storage purposes

C – Protection of a complete watch for manipulation in the boutique

Aim and impact

To replace the manual application of protective coatings within the watch manufacturing cycle by a digital (drop-on-demand) printing with a subsequent traceless removal.

State of the art:
Manual application*

Industry needs / challenges:
Digital printing

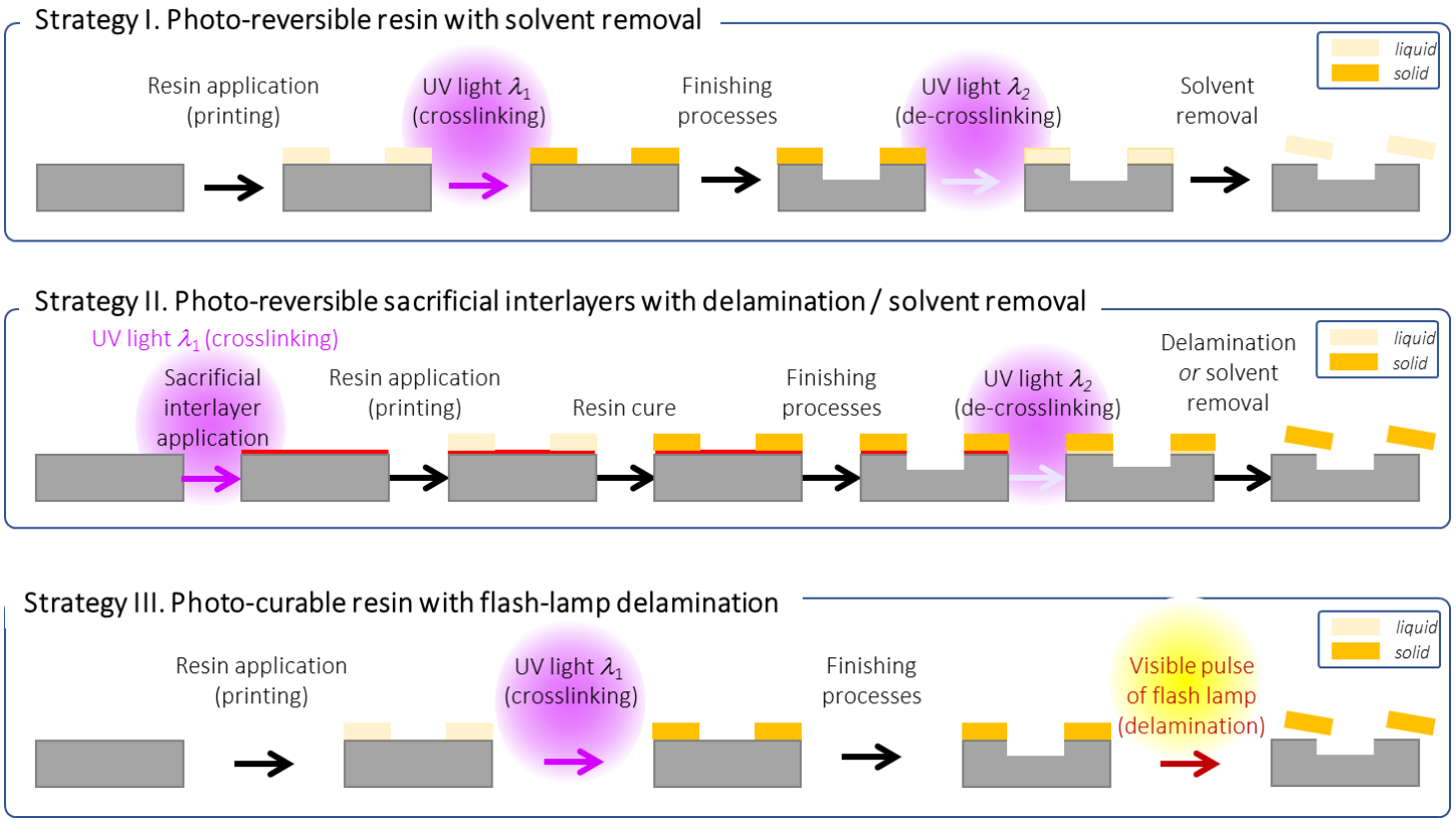
- Develop printable photocurable resins
- Identify suitable printing methods
- Peelable films that do not leave traces

Expected impacts:

- **New masking designs** with finer features down to 10 µm.
- **Process automation** (higher throughput and yield expected)

* www.metalem.ch

Approach


Strategy I. Photo-reversible resin with solvent removal
liquid
solid
Resin application (printing)
UV light λ_1 (crosslinking)
Finishing processes
UV light λ_2 (de-crosslinking)
Solvent removal
Strategy II. Photo-reversible sacrificial interlayers with delamination / solvent removal
UV light λ_1 (crosslinking)
Sacrificial interlayer application
Resin application (printing)
Resin cure
Finishing processes
UV light λ_2 (de-crosslinking)
Delamination *or* solvent removal
liquid
solid
Strategy III. Photo-curable resin with flash-lamp delamination
liquid
solid
Resin application (printing)
UV light λ_1 (crosslinking)
Finishing processes
Visible pulse of flash lamp (delamination)

People and Institutions

Partners	EMPA – TFPV/FP	EPFL - LPAC	ETHZ-ME	ASRH
PI	 Yaroslav Romanyuk  Jacob Heier	 Yves Leterrier	 Mark Tibbitt	 Fabienne Marquis
Postdoc	 Vitor Vlnieska			
PhD students		 Alper Balkan	 Morris Wolf	

Dübendorf
Zürich
Neuchâtel
Lausanne

Industrial partners

BERLAC
BERLAC GROUP

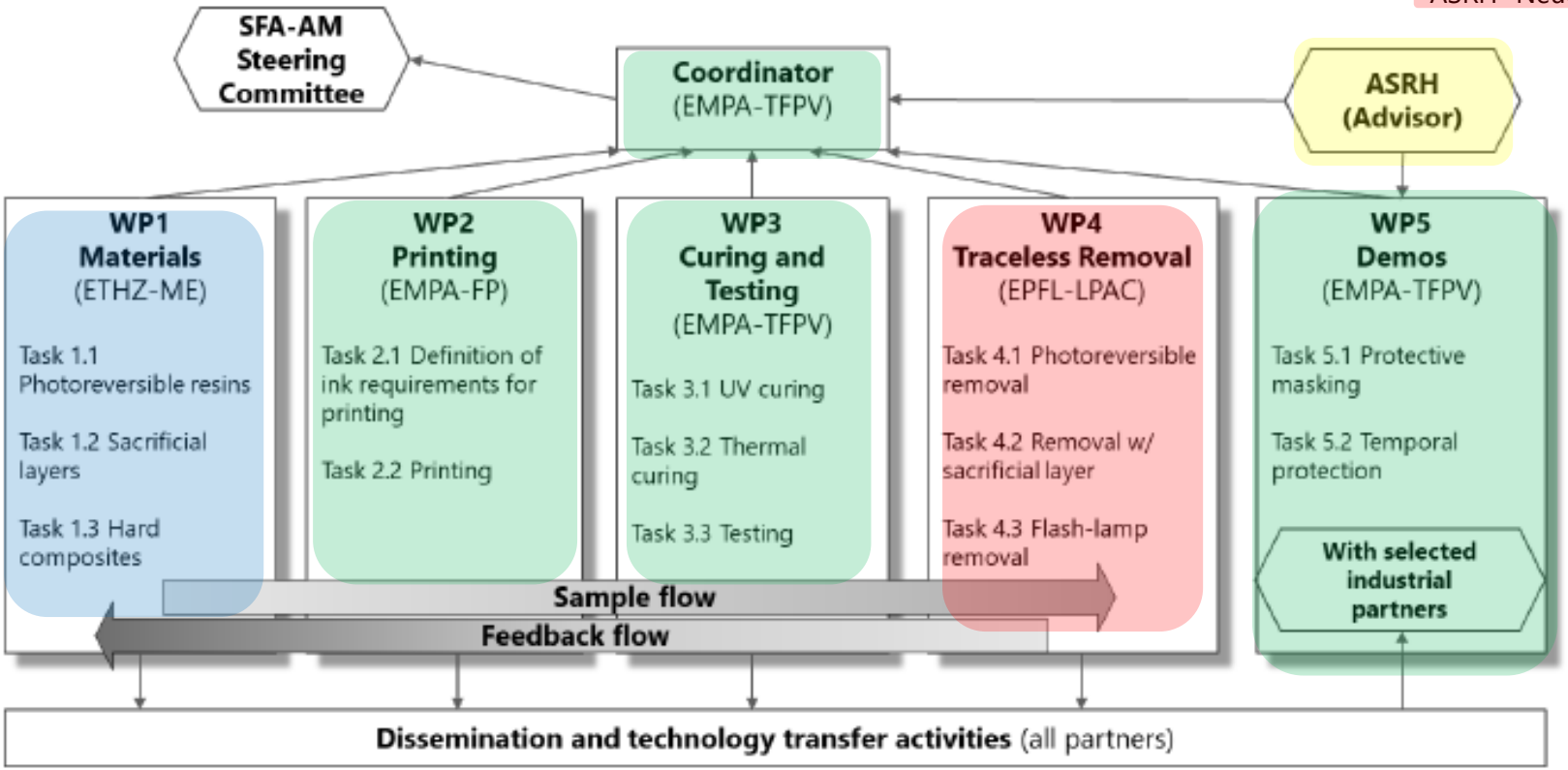
SWATCH GROUP
THE SWATCH GROUP RESEARCH AND DEVELOPMENT LTD

OPTOMEC™
Directed Material Deposition™ Solutions

CIPOSA
Automatisation en Micro-Assemblage

Project Organization

EMPA - Dübendorf
ETH - Zürich
EPFL - Lausanne
ASRH -Neuchâtel



Objectives

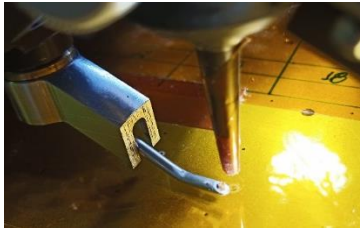
1. Develop photo-reversible materials that can serve as protective coatings (ETHZ – ME)
2. Develop nanocomposite “hard” coatings (EPFL – LEPAC)
3. Demonstrate printability of photopolymers with a min. feature size down to 10 µm using AJP technique (EMPA – TFPV-FP)
4. Ensure traceless removal either by dissolution or by peeling (EMPA – TFPV-FP)
5. Explore flash lamp for non-contact removal method (EMPA – TFPV-FP)

State of the art:
Manual application*

Demo1: watch dial with 2D flat shape of specific rugosity, with protective line structures (1–10 mm, linewidth down to 10 µm) against a galvanic bath or abrasion;

Demo2: watch case with a printed or sprayed protective film (5–20 mm dimension) that can be detached by a non-contact method

Automation + high precision printing

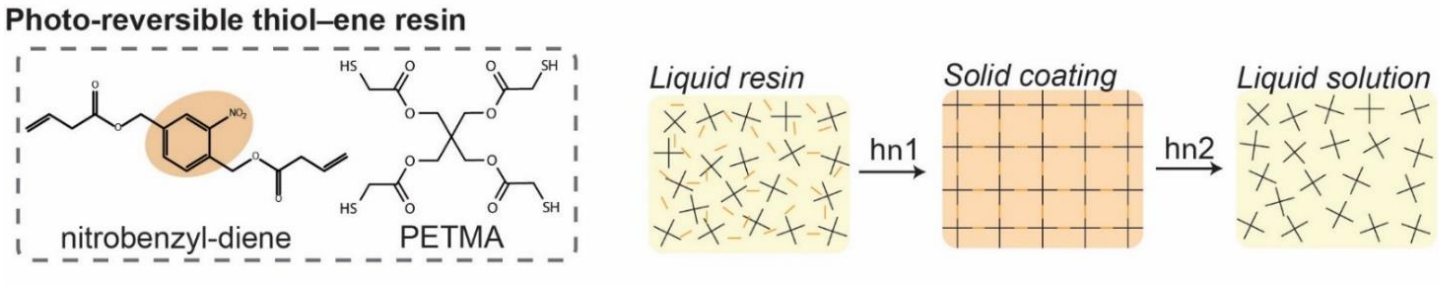


First results: photopolymer synthesis

ETHZ-ME

Mark Tibbitt

Morris Wolf



- After protocol optimization, Nitrobenzyl-diene has been **successfully synthesized** (following Radl 2015)

Resin formulation evaluation:

- Liquid resin (nitrobenzyl-diene, PETMA, and photoinitiator) formed a **stable network** with 405nm light

S.Radl, S. Schlögl et. al., Photocleavable epoxy based materials, Polymer, Volume 69, 2015, Pages 159-168

First results: Photo-reversible nanocomposites

- Synthesis of thiol-ene nanocomposites
  (Commercial resins and lacquers as benchmarks)

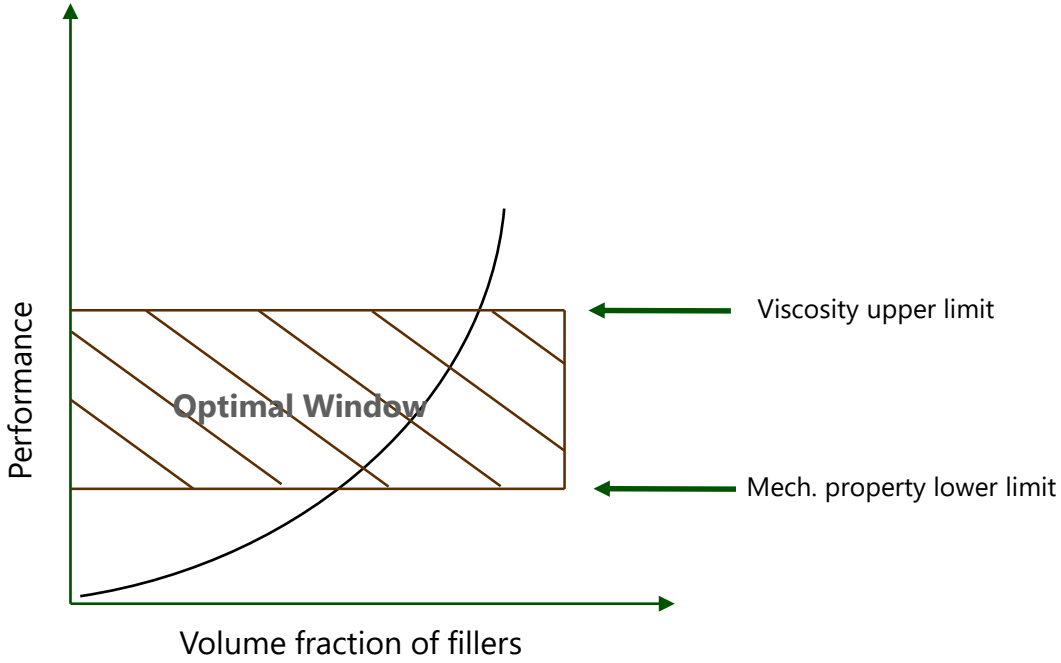
Mech. properties ↑ Viscosity ↑

Printability ? Reversibility ?

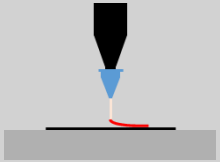
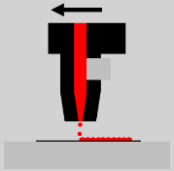
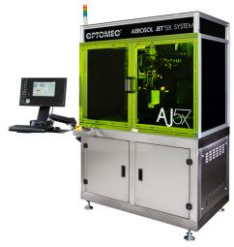
EPFL - LPAC

Yves Leterrier

Alper Balkan



Overview of printing methods

	Spraycoating (NadeTec ND/SP)	**Dispensing** (Image master Musashi)	**Inkjet** (PixDro LP50)	**Aerosol jet** (Optomec AJX-5)
Linewidth	-	40 µm	40 µm	25 µm
Viscosity	< 50 cP	up to 50000 cP	8 – 12 cP	10 – 500 cP
Precision vs Cost				
	Precision/cost			
Equipment Snapshot				

EMPA – TFPV/FP

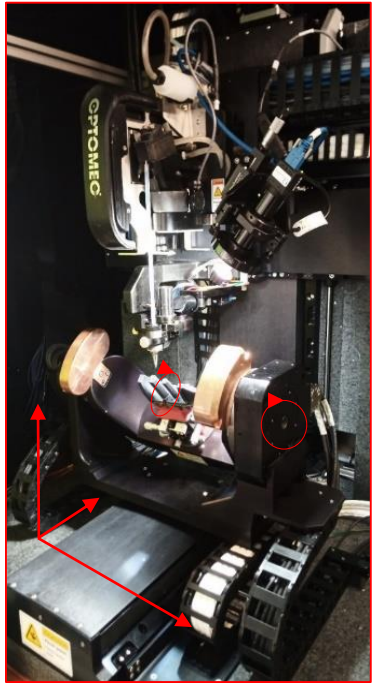
Yaroslav Romanyuk

Jacob Heier

Vitor Vlnieska

First results AJP

Work flow:



CAD Design (DXF)

↓

ACSPL+ programming language

↓

Verification

↓

Printing

Chemistry
Viscosity
Particle size

Photoresist | Bitumen lacquer | Acrylate lacquer

-Printabilily of commercial lacquer are not realizable.

-Printabilily of photoresists is realizable

- Fine and large feature coating presented reliable results
- Fine feature coating stability: line width 30 µm
- Satelite droplets are a side effect to live with

EMPA – TFPV/FP

Yaroslav Romanyuk

Jacob Heier

Vitor Vlnieska

Outlook

ETHZ-ME

- Photocleavability is being investigated with <365nm UV-light
- Printable formulations of the resins will be prepared

EPFL - LPAC

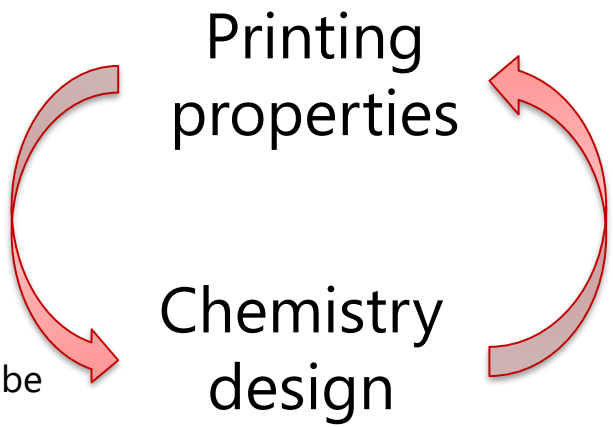
- Acquisition of the UVC source and building of the 'photo-reversible' setup
- experiments with oNB resins and nanoparticles

EMPA – TFPV-FP

- Installation of dispensing equipment (April – May 2022)
- Printability of dispensing, spraying, and inkjet techniques to be evaluated

All participants:

- Until month 24: a photo-reversible resin that can be printed on a flat metal substrate and detached by light-induced method.



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Thank you for your attention