ASTech Paris Region

RESCOLL Société de Recherche

Latest achievements in the field of assembling metals and composites

ASTech International Conference MMP 2015

November 25th, Deauville

WHO WE ARE

RESCOLL
Société de Recherche

SME dedicated to materials

Anaysis, Testing, Audit, Expertise

Contractual Innovation Studies (Bonding, coatings, composites, etc.)

Proprietary Technologies

Professional Training

SOME FIGURES

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55%

ASD

20%

HEALTH

10%

ENERGY

15%

OTHER

- >1000 Customers (20% export)
- >50 patents following studies
- 10.5M€ turnover in 2014
- 50% of Turnover in contractual R&D

- 80 employees (PhDs, Engineers, Technicians)
- 7000m² fully equiped laboratories
- 18 proprietary patents

QUALITY

- ISO 9001 Certification
- COFRAC ISO 17-025 Accreditation

« Tests on Composites, food contact materials, medical devices »

- COFRAC ISO 17-020 *« EcoTechnologies Verification »* Accreditation

- Fire Testing Certification : FAR25

- NADCAP (NMMT) Accreditation

- SAFRAN Qualification (FAL518)
- AIRBUS Qualification
- GE Qualification

TRAINING

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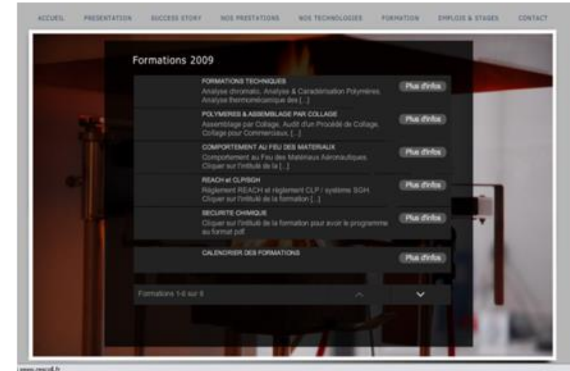
Agreed training center since 2001

- Numerous training programs available (Inter and intra)
- Various topics adressed : bonding, polymers, testing, regulation, etc.
- Graduating Trainings (EWF):
  Bonding for bonders and specialists



Some references

BONDING – Our core expertise

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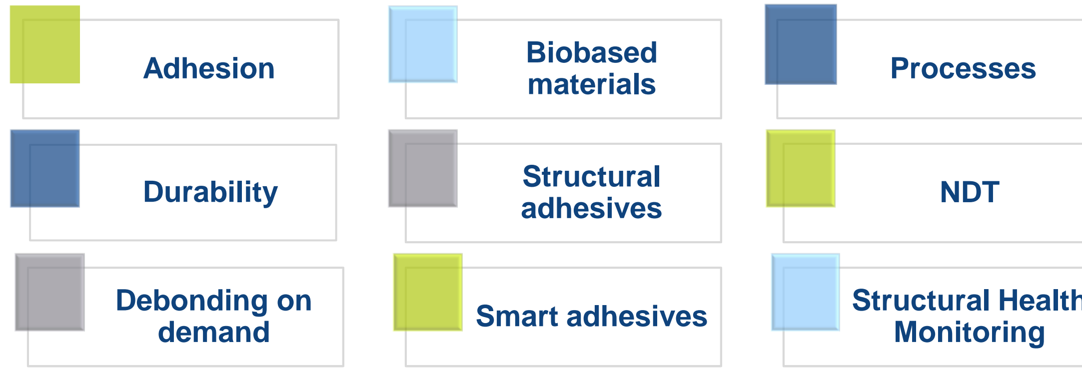
RESEARCH AREAS



COMPETENCES

Formulation

Established expertise in debonding on demand

Development of customized formulations (conductive, fire resistant, REACh compliant, biosourced)

Benchmarking & Process development

Benchmark and selection of best bonding solutions

Production of bonded assemblies (test coupons and products)

Development & qualification of bonding systems and processes

REFERENCES

MICHELIN, FIAT AUTO, SAFRAN, AIRBUS DEFENSE & SPACE, THALES, TECNIP, in various industry sectors (luxury, space, defense, transportation)

MAIN EQUIPMENT

Bonding and surface preparation labs
Table-top surface treatment stations (chemical) and plasma activation systems
Planetary mixers (2x250g and 2x830g capacity)
Dissolvers equiped with vaccuum chamber
3-roll mill
Bonding jigs
Dosing and adhesives dispensing systems
Curing ovens
UV Fusion bench
Dynamometers (static and fatigue, 100N to 250kN)
METRAVIB DMA+150
Climatic chambers
Ultrasonic NDT

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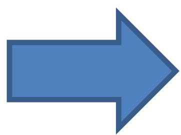
Bonding: Pros & Cons

Ever increased use of joining of dissimilar materials in new industrial developments



Bonding is a key solution identified in technological roadmaps of major aircraft manufacturers, since bonding means

- *Lightness*
- *Better load distribution (compared to other joining techniques)*
- *Less impact on substrates (curing temp, no drilling)*
- *Good sealing*

But several challenges exist

- *E&T conduction*
- *Debonding on Demand*
- *Limited temperature resistance (polymeric materials)*
- *NDT*
- *Surface treatments*
- *Durability*

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Bonding: Pros & Cons

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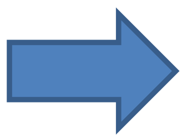

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- ***E&T conduction***
- ***Debonding on Demand***
- ***Limited temperature resistance (polymeric materials)***
- *NDT*
- *Surface treatments*
- *Durability*

BONDING – KEY PROJECTS

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E&T CONDUCTIVITY

Adhesives : insulative materials

Numerous products available on the market but they are :

- ***Expensive (costs of fillers)***
- ***Dense (fillers)***
- ***Not suitable for use in structural applications***

There is a need for new cheap adhesives, with lower density and better mechanical strength

E&T CONDUCTIVITY

e&T conductive structural adhesives

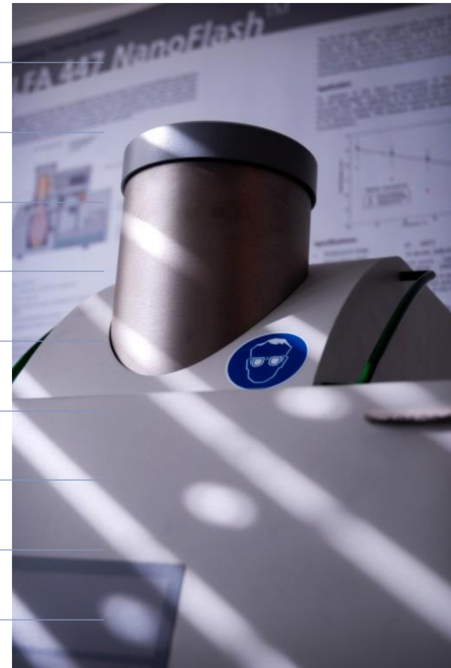
eT-Bond National Project (end users: AIRBUS DS, THALES)

Thermal conductivity (W/m.K)

10
9
8
7
6
5
4
3
2
1
0

0 5 10 15 20 25 30

Lap shear strength (Mpa)



BONDING – KEY PROJECTS

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E&T CONDUCTIVITY

e&T conductive structural adhesives
eT-Bond National Project (end users: AIRBUS DS, THALES)

	Raw adhesive	Rescoll Metal based Adhesive tech	Rescoll Cabon based Adhesive tech	Rescoll Ceramic based Adhesive tech
Thermal conductivity	0,2 W/m.K	Up to 4 W/m.K	Up to 4 W/m.K	Up to 4 W/m.K
Electrical conductivity	insulative	Up to 10^E5 S/m	Up to 1 – 10 S/m	Insulative

BONDING – KEY PROJECTS

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E&T CONDUCTIVITY

e&T conductive structural adhesives

eT-Bond National Project (end users: AIRBUS DS, THALES)

	Electrical Conductivity S/cm	Thermal Conductivity W/mK	Lap Shear Strength MPa
Specs for Thermal Adhesive	1.10E^{-5} to 1.10E^{-3}	>4	>9
Base Material (unmodified adhesive)	1^{E-15}	0.2	24
Thermal Adhesive	6	4.4	10

	Electrical Conductivity S/cm	Thermal Conductivity W/mK	Lap Shear Strength MPa
Specs for Structural Adhesive	>100	>0.8	> 15
Base Material (unmodified adhesive)	1^{E-15}	0.2	24
Structural Adhesive	300	1	19

2 adhesive formulations validated by end users and now part of STRUCTIL's port-folio

BONDING – KEY PROJECTS

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INDAR (INnovative Dismantling Adhesives Research)

Who needs to debond on command?

Many applications, at different product stages

- **Maintenance**
  - **Replacement of worn parts**
  - **Upgrade of components**
- **End of life**
  - **Sorting-recycling of dissimilar bonded assemblies**
  - **Recovering of parts for the second-hand market**
- **Temporary Fixing**
  - **Machinning**
  - **Release on command (in flight- space applications)**
  - **Proof tests**
  - **Bonding of sensors (on planes, cars, …)**
- **Safety**
  - **Vents with restricted access (instead of screwed panels)**

Requirements for a debondable structural adhesive

Processing

- Similar to adhesives used for the application
  - No specific tool/machine needed
  - No shelf life or gel time limitation

Life in service

- Similar to standard adhesives
- No anticipated debonding of the parts or depletetion of the adhesive strength of the assembly
- Ageing performance and durability should remain unchanged

Debonding step

- Easy and unambigous triggering (i.e. activation must be simple and reliable)
- As fast as possible (depending on the parts to disassemble)
- Clean substrates surfaces after debonding (easier re-use, recycling of the parts)

Main idea: How to find a compromise between durability and the release function?

BONDING – KEY PROJECTS

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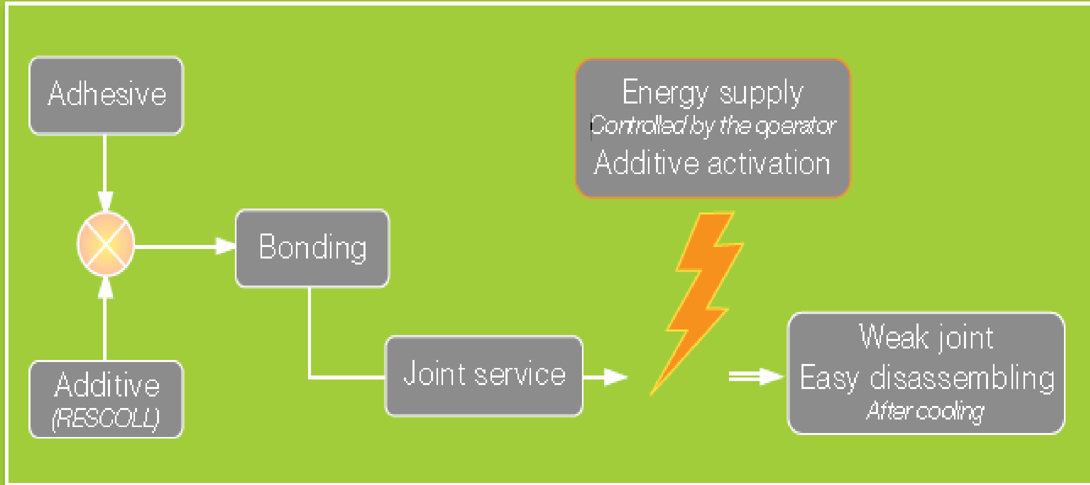
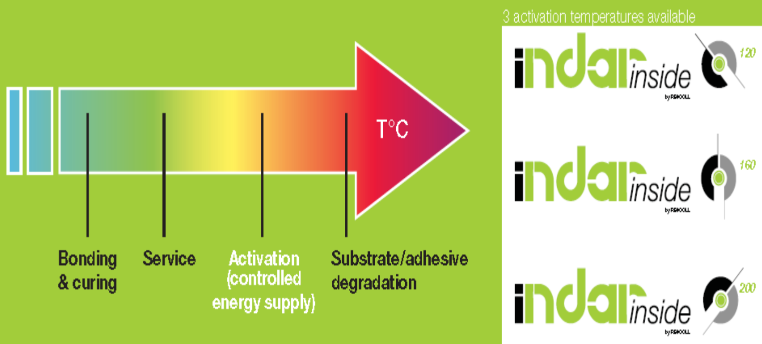
INDAR (INnovative Dismantling Adhesives Research)



Bonding operation
No modification of shelf life and ageing of the adhesive formulation (H7, etc.)

Thermal activation
Adapted and localized energy delivery Scale 1 test of industrial energy sources

Dismantling
Dismantling of scale 1 samples : backlite, PP skin and spoiler bonded on an SMC frame.
Clean surfaces after dismantling : easier re-use & recycling



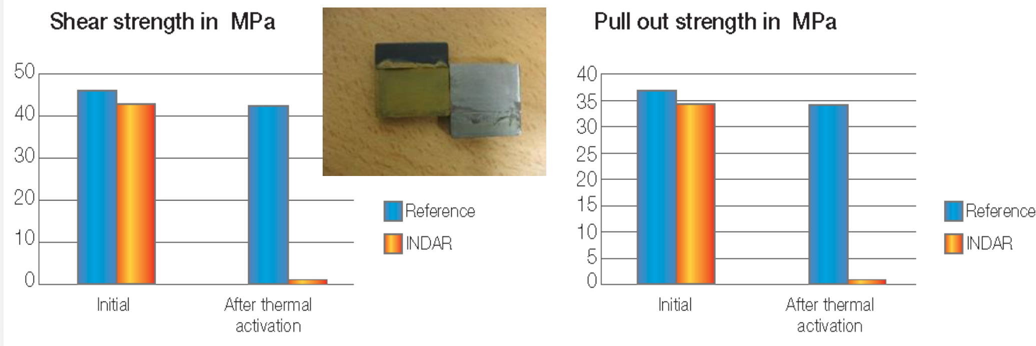
3 Temperature ranges

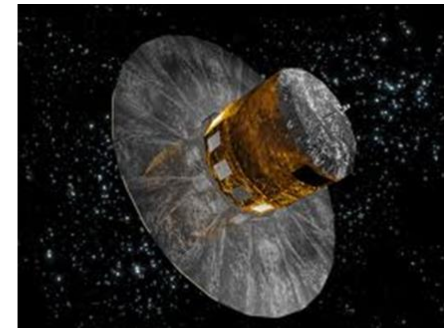
Compliant with various adhesive types

BONDING – KEY PROJECTS

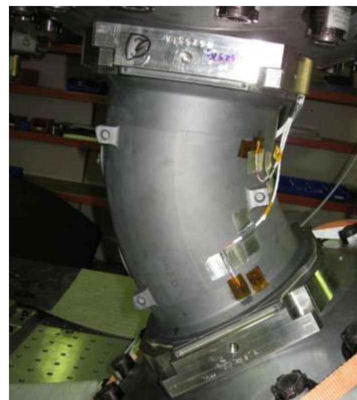
INDAR (INnovative Dismantling Adhesives Research)

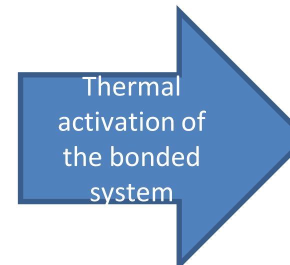
Development of a structural debondable adhesive for ground testing of GAIA SiC structuree

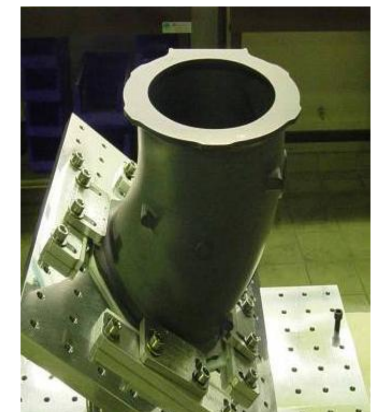




Training -Transfert







Process qualification and ground testing

BONDING – KEY PROJECTS

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INDAR (INnovative Dismantling Adhesives Research)

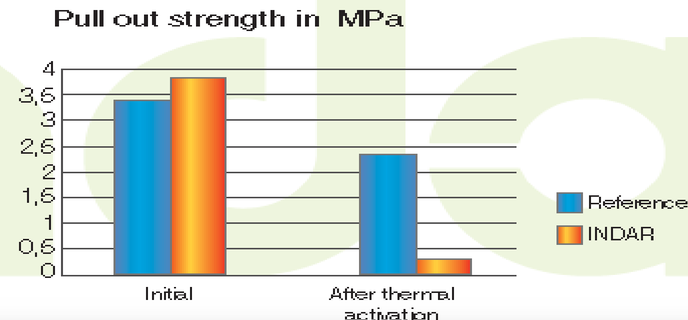
Bonds that debond…

An ecoconception of cars for further environmental friendly dismantling

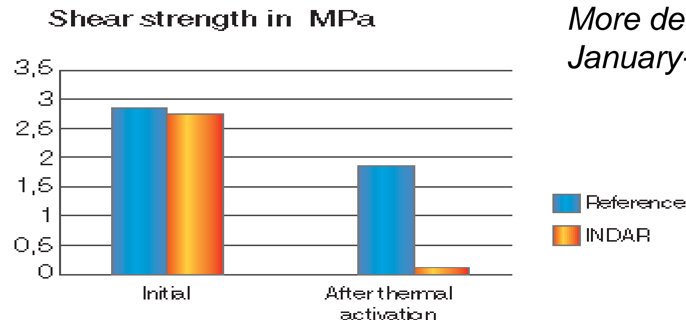
A European Project supported within the Sixth Framework Programme for Research and Technological Development

Tempered glass bonded on metal with 1K polyurethane (industrial reference modified with INDAR)

Peel failure type	Initial	After thermal activation
Reference	Cohesive in adhesive	Cohesive in adhesive
INDAR	Cohesive in adhesive	Adhesive between adhesive & glass



PP bonded on SMC with 1K polyurethane (industrial reference modified with INDAR)



More details: JEC COMPOSITES MAGAZINE – ISSUE #46 – January-February 2009

- No visual degradation or deformation of the PP substrate
- Clean surface of the SMC substrate

BONDING – KEY PROJECTS

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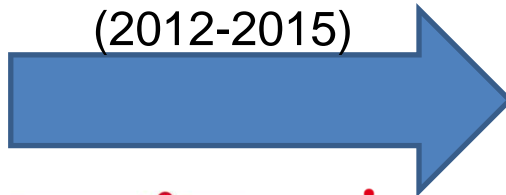
INDAR (INnovative Dismantling Adhesives Research)

Debonding, a challenge not only for adhesives but also for paints!

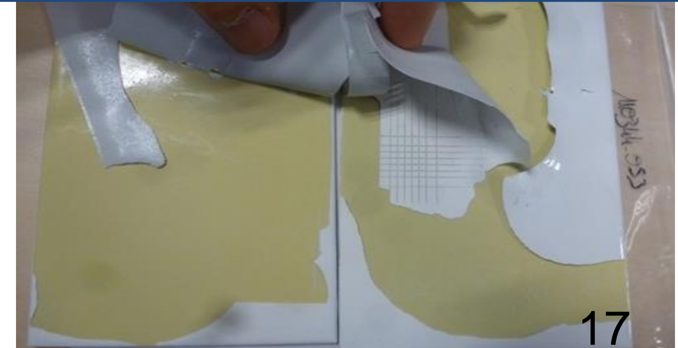
Stripping: slow and dangerous process

FOURMI PROJECT (2012-2015)



Development of a heat triggered selective stripping process

- Selective removal of the topcoat
- 100% solid wastes
- Easy recovering of the clean and non-damaged epoxy primer



BONDING – KEY PROJECTS

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Development of Room Cure 2 Component Epoxy Adhesives with Extended Service Temp

Adhesives are polymers: limited high temperature resistance
Generally , the higher the curing temperature the higher the thermal resistance (Tg)

However:

- ***Several components of top class epoxy formulations may not be REACH compliant in the near future***
- ***Many applications allow limited temp curing (<80°C), especially in ASD but wide service temperature range (eg: -90 to +150°C)***

Need for better understanding of the interaction between curing conditions, adhesive composition and final thermomechanical properties

New adhesive formulations based on up-to-date components (resins, hardeners, tougheners, etc.)

BONDING – KEY PROJECTS

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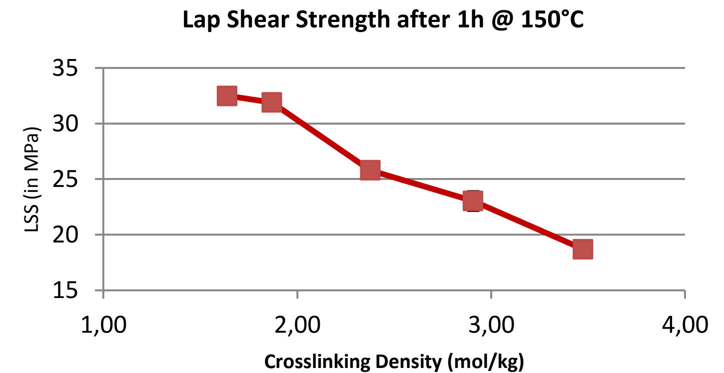
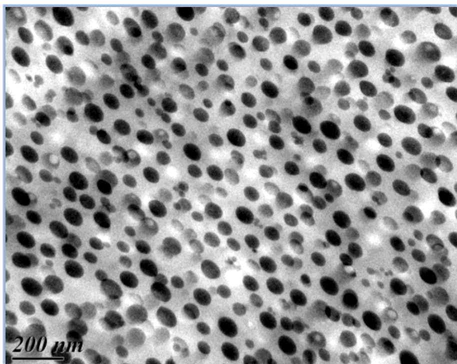
Development of Room Cure 2 Component Epoxy Adhesives with Extended Service Temp

Relationship between network chemical structure and thermomechanical properties of the epoxy adhesives:

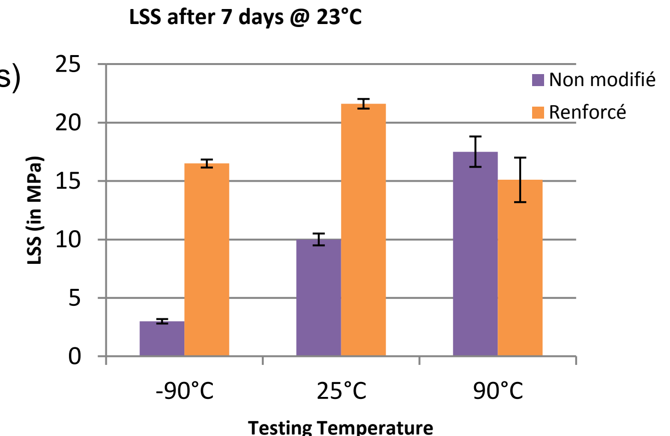
- **Curing conditions**: 23°C / Température
  - ➔ impact on thermomechanical properties
- **Components**
  - ➔ Resins : DGEBA, novolacs, …
  - ➔ Hardeners : polyamidoamines, polyetheramines, …



Study on « Tougheners » :



- ➔Core-Shell Rubber
- ➔Block Copolymers (CTBN and others)
- ➔Nanosilica



BONDING – KEY PROJECTS

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Development of Room Cure 2 Component Epoxy Adhesives with Extended Service Temp

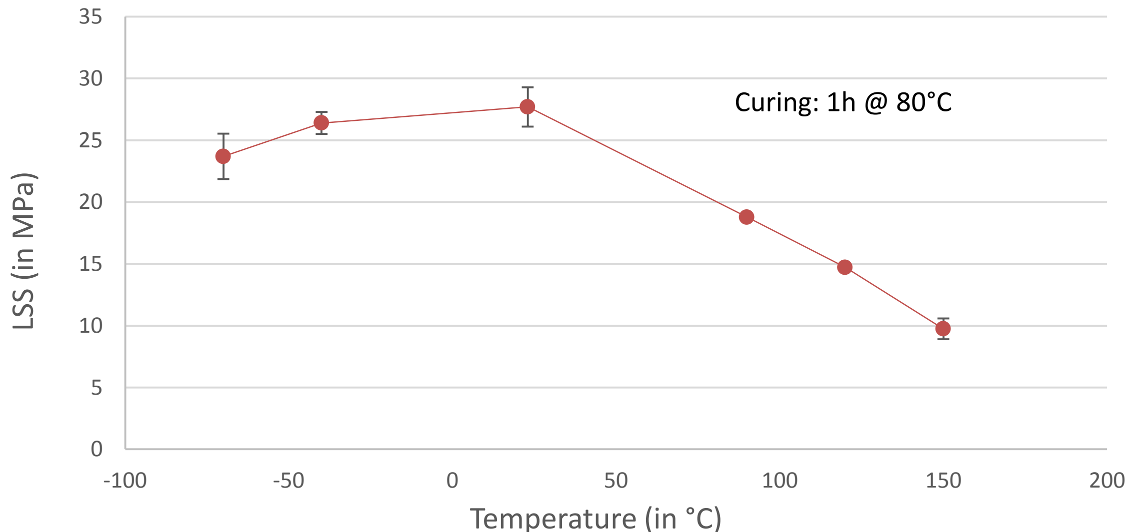
Example of Results

-**Curing conditions**: 23°C / Température (<80°C)

-**Gel Time >60min** @ Room Temp

- **Typical peel resistance >50N/cm** @ Room Temp

-**LSS > 10MPa between -70 and +150°C (on chemically etched 2024 Al)**



BONDING – KEY PROJECTS

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ASTech Paris Region

COMPOCHOC (19th FUI Call)

Laser Shock NDT

Generation of localized traction loads

- *Quantitative NDT*
- *Detection of kissing bonds*

LASER

Shock Wave

Free Surface

Traction

- Strong interface
- ➔ No damage
- Weak interface
- ➔ Interface failure

Experiments

1. Identification of debonding levels

Growing Intensity Level [GW/cm²]

2. Characterization of the assembly response

Time

Shock

P1 0 z

COMPOSITE JOINT COMPOSITE

SIMULATIONS

1. Validation of models

2. Complete understanding and control of phenomena

OPTIMISATION

1. Definition of optimum shock configurations per assembly

2. Definition of laser parameters

CONCLUSIONS

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BONDING: ***a key technology for joining of dissimilar materials***

But new assemblies need to optimize synergies of materials benefits (strength, lightness, conductivity, fatigue resistance, etc.), **adhesives needs to be multifunctionnal**

Stronger regulation pressure on materials manufacturers, especially adhesive formulators. Risk of **obsolescence of old high performance formulas** in the near future

More **regulatory pressure** on goods manufacturers **regarding end of life**

- Needs for recycling, especially new and widespread dissimilar assemblies
- Easier recovery/maintenance of parts is targeted to extend product life span

Debonding on command gives an open choice to engineers and designers for materials assembling: adhesive may be considered for applications where lack of reversibility is a No-Go

In a few words, future multifunctionnal structural adhesives will bring more service performance/reliability and complete loss of adhesion by the push of a button!