e-Xstream engineering is a software and engineering services company 100% focused on the advanced micromechanical modeling of multi-phase materials such as composites. 


DIGIMAT-MF and DIGIMAT-FE software are used to predict the thermo-mechanical behavior of a large variety of multi-phase (e.g. composites) materials based on the knowledge of their microstructures. 

DIGIMAT is seamlessly interfaced with major CAE software such as ANSYS to offer an advanced multi-scale modeling solution aimed at the accurate and efficient prediction of the thermo-mechanical behavior (stiffness, vibration, creep and relaxation, impact and failure...) of a large variety of composite parts used across the industries.

TARGET CUSTOMERS

The market segments targeted by DIGIMAT and DIGIMAT to ANSYS interfaces are:

1. Multi-Phase Material Suppliers who need to design optimal material and to support their end-customers in their effort to select the optimal material and model its influence on the final part performance.
   a. Engineering Plastics such as Glass or Carbon fiber reinforced thermoplastics (e.g. PPGF, PAGF, etc.)
   b. Rubber with carbon black or silica fillers.
   c. Carbon Fiber Composites such as Carbon Fiber Reinforced Plastics and Carbon/Carbon composites.
   d. Hard Metals such as Tungsten Carbides (CoWC);
   e. Polymer Nano Composites with nano-fillers and carbon nano tubes.

2. End-Users of Multi-Phase (Composite) Materials who need to select the optimal material for the optimal part performance by accurately modeling the performance of such parts taking into account the actual nonlinear and anisotropic material behavior as induced by the manufacturing process (e.g. Fiber orientation induced by injection molding).
   a. Automotive: OEMs & Suppliers
   b. Aerospace: OEMs & Suppliers
   c. Consumer Goods: Mobile Phones, Consumer Electronics, …
d. Industrial Goods: Electric Connectors, Cutting and wear parts,…
e. Tires and Anti-Vibration Systems.

Reference Customers

The following customers are using DIGIMAT and DIGIMAT to ANSYS software.

Material Suppliers

✓ Rhodia Polyamide (France): Reinforced Plastics
✓ EMS Chemie (Switzerland): Reinforced Plastics

Automotive

✓ Brose (Germany): 1st Tier Supplier

Consulting Services

✓ Prolimex (Germany): Simulation Service Provider.
Fig. 1 DIGIMAT Graphical User Interface.

e-Xstream software products of interest to ANSYS customers are listed below. Please refer to the Product Portfolio document and to the product data sheet for a more detailed description of each product.

**DIGIMAT-MF, Mean Field Homogenization of Multi-Phase Materials**

DIGIMAT-MF is micromechanical material modeling software that enables one to predict the linear and nonlinear anisotropic thermo-mechanical properties of a multi-phase material based on the thermo-mechanical properties of each material phase and on the description of the material microstructure morphology defined by the reinforcement(s) phase(s) content, shape and orientation.
**DIGIMAT-MF uses semi-analytical mean field homogenization technology based on Eshelby’s Theory.**

The main advantages of DIGIMAT-MF are:

1. **Ease of use**: The material can be defined in less than 10 minutes.
2. **CPU performance**: The composite properties are usually computed in less than 1 minute.
3. **Accuracy**: the prediction of the macroscopic composite response and average fields in each phase of the material is validated against available test data.
4. **Multi-Scale Coupling with FEA**: where DIGIMAT-MF is used as a micromechanically-based material law at each integration point of a structural FEA model.

**DIGIMAT-MF, Virtual Material Lab**

**Material Behavior**
Prediction of thermo-mechanical, elastic, elastic-plastic, time-dependent and hyperelastic composite properties under monotonic or cyclic loadings.

**What If?**
Fast explorative design of new materials. Ability to predict the influence of added material on composite response.

**Parametric Studies**
Sensitivity of composite response to fiber orientation, fiber shape, component weight fractions, component stiffness...

→ **Accurate & Efficient prediction of linear, nonlinear & time-dependent thermo-mechanical properties as a function of materials’ microstructure**

**Fig. 2** The Graphical User Interface of DIGIMAT-MF that is used to define and to predict the thermo-mechanical behavior of multi-phase materials using state-of-the-art nonlinear micromechanics.

**Fig. 3** DIGIMAT-MF to perform “what if” analysis and to predict the influence of the microstructure parameters on the final behavior of the material.

The main limitations of DIGIMAT-MF are:

1. **Ellipsoidal Inclusion**: The inclusions are assumed to have an ellipsoidal shape defined by 1 aspect Ratio (Length/diameter).
2. **Average Field**: only average values (stress, strain,...) are available per phase. The detailed field distribution is not predicted.

These 2 limitations are removed in DIGIMAT-FE described below.
DIGIMAT-FE, Finite Element Modeling of Material Representative Volume Elements (RVE)

DIGIMAT-FE is a micromechanical material modeling software that enables one to predict the linear, nonlinear and anisotropic thermo-mechanical properties of a multi-phase material based on the thermo-mechanical properties of each material phase and on the description of the material microstructure morphology given by the reinforcement(s) phase(s) content, shape and orientation.

DIGIMAT-FE is used to generate complex microstructure geometries that are representative of the real material. The microstructure geometry can then be meshed, using ANSYS® ICEM CFD™, and solved using ANSYS Mechanical FE solver.

**Fig. 4** DIGIMAT-FE enable one to generate Representative Volume Elements (RVE) of realistic materials that are exported to ANSYS® ICEM CFD™ for meshing and to ANSYS® for analysis. The material specific pre and post-processing is done in DIGIMAT-FE.
DIGIMAT Interfaces to Injection Molding Software

DIGIMAT interfaces to the injection molding software listed below enable DIGIMAT users to read in the fiber orientation induced by the injection molding process simulation and take into account the effect of fiber orientation on the anisotropic behavior of the material at each local point of the structure. DIGIMAT to injection molding software interfaces also take into account the effect of injection molding induced stresses and temperature.

- DIGIMAT to MOLDFLOW
  - DIGIMAT to Moldflow Mid-Plane
  - DIGIMAT to Moldflow 3D
- DIGIMAT to 3D-SIGMA
- DIGIMAT to Moldex3D

Fig.5 DIGIMAT is interfaced to the major injection molding software to enable ANSYS users to perform accurate nonlinear analyses of engineering plastics parts taking into account the local fiber orientation induced by the injection molding process.

Fiber orientation, stresses and temperature are mapped from the injection molding mesh to the structural analysis mesh using MAP described below.
Interaction between DIGIMAT and ANSYS FEA Software

DIGIMAT-MF is strongly coupled to ANSYS via the Material User Subroutine (USERMAT). DIGIMAT to ANSYS interface is provided as pre-compiled library to enable accurate and efficient nonlinear multi-scale structural modeling where DIGIMAT-MF acts as the micromechanical material model that takes into account the behavior of the material constituents and the morphology of the underlying microstructure at each element/integration point of the ANSYS finite element mesh of the structure.

**Interaction between DIGIMAT and ANSYS FEA**

**Classical FE process**
- FE model level
- Nodal coordinates, ...
- Internal forces and element stiffness
- Element level
- Strain increments, material state, ...
- Stresses and material stiffness
- Material level
- \[ \epsilon \]
- \[ \sigma \]
- « In code » model

**Coupled FE/DIGIMAT process**
- FE model level
- Nodal coordinates, ...
- Internal forces and element stiffness
- Element level
- Strain increments, material state, ...
- Stresses and material stiffness
- Material level

Fig. 6 DIGIMAT-MF is strongly coupled to ANSYS where it can be used as a “User Defined Material” to enable nonlinear multi-scale material and structure modeling from within ANSYS. In this case, DIGIMAT-MF can be seen as a micromechanically-based material model acting at each relevant integration point of the ANSYS FE model.
For engineering plastic suppliers and end-users, MAP offers the capability to transfer fiber orientation, residual stresses and temperature from the injection molding mesh to the optimal ANSYS mesh, where they can be used by DIGIMAT to ANSYS to perform state-of-the-art nonlinear multi-scale analysis.

**Fig. 7** Mapping of fiber orientation from Moldflow Mid-Plane Triangular Mesh to ANSYS quadrangular multi-layered shell mesh. MAP enables ANSYS users to define the optimal mesh refinement and to choose the right element for the right structural FEA.
COMPETITIVE ADVANTAGE

The Competitive advantage of e-Xstream and DIGIMAT are:

1. A unique software platform for the accurate and efficient prediction of the nonlinear anisotropic material behavior as a function of the underlying material microstructure.
2. Strong coupling with advanced FE solvers to enable nonlinear multi-scale modeling of composite parts where the material is modeled using state of the art nonlinear micromechanical technology.
3. Interfaces to injection molding software to bridge the gap between the process and end-performance simulation of injection molded parts made of reinforced plastics.
4. A motivated team with a strong expertise in nonlinear material and nonlinear structural FEA.
5. A strong industrial expertise in plastics, rubber, hard metals and nano-composite materials.

SALES MODEL

DIGIMAT licenses are managed using FlexNet license management technology. We support the following type of licensing schemes:

- Fixed duration (i.e. lease) or Perpetual (i.e. paid-up) licenses; Leased license include maintenance and support. Paid-up license include the first year maintenance and support. The maintenance and support for the following years is optional and has to be contracted separately.
- Node Locked or Floating;

The use of a DIGIMAT product is enabled by a combination of product-specific seat (S) and a number of tokens (T) as summarized below:

1. Product Specific Seat (S). 1 seat is needed per product use. The price of a seat is product specific.
2. Tokens (T) are common and interchangeable between all DIGIMAT software modules. The price of a T is common to all products. The number of tokens needed per product use depends on the product being used as describe in the table below:

<table>
<thead>
<tr>
<th>Software Product</th>
<th>S</th>
<th>T</th>
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<tbody>
<tr>
<td>DIGIMAT</td>
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<td>0</td>
</tr>
<tr>
<td>DIGIMAT-MF</td>
<td>1</td>
<td>10</td>
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<tr>
<td>DIGIMAT-FE</td>
<td>1</td>
<td>10</td>
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<tr>
<td>DIGIMAT to Moldflow MP</td>
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<tr>
<td>DIGIMAT to Moldflow 3D</td>
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</tr>
<tr>
<td>DIGIMAT to ANSYS</td>
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<td>5</td>
</tr>
</tbody>
</table>

- Entry level license includes: 1 Seat of DIGIMAT + 1 Seat of DIGIMAT-MF + 10 T. This license will allow you to use DIGIMAT-MF to compute the micromechanical linear and nonlinear behavior of reinforced materials.
- To use DIGIMAT to model the material behavior within ANSYS you just need to add: + 1 S of DIGIMAT to ANSYS. The 5 T are already available from the pool of 10 T included in the entry level DIGIMAT license.
- To use DIGIMAT with ANSYS taking into account fiber orientation computed by injection molding software like Moldflow 3D you just need to add: + 1 Seat of DIGIMAT to Moldflow 3D. No Tokens are required in this case.
DIGIMAT interactive GUIs are available on Windows 32 or 64 bits OS. DIGIMAT MF and FE solves are available on Redhat or Suse 64 bits platforms.

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