Release 4.4.1 — April 2013

For a fast & accurate prediction of the nonlinear behavior of multi-phase materials using Mean-Field homogenization technology.

For an accurate prediction of the local/global nonlinear behavior of multi-phase materials using FEA of realistic Representative Volume Element (RVE).

For the preparation, storage, retrieval and secure exchange of Digimat material models between material suppliers and users, while protecting Intellectual Property.

Interfaces to process and structural FEA codes for an accurate prediction of composite materials and reinforced plastics parts performance using non-linear multi-scale modeling approach.

For an efficient mapping of scalar & tensorial data between dissimilar shell and solid FE meshes.

For an easy and efficient design of honeycomb sandwich panels using state-of-the-art micromechanical material modeling technology.
Mean-Field homogenization software used to predict multi-physical nonlinear behavior of multi-phase materials.

Analyze your multi-phase composite materials in an accurate, efficient and easy way!

NEW IN Digimat 4.4.1

- **Materials** — modeling of long fiber thermoplastics & woven composites
- **Failure** — strain based Tsai-Hill 3D transversely isotropic & improvements in FPGF
- **Fatigue** — matrix based fatigue model
- **Creep** — creep & relaxation loading in GUI
- **Temperature dependencies** — plastic strain multipliers as f(T)
- **Time dependencies** — user definition of time dependency of material parameters

**MAIN CAPABILITIES**

**Nonlinear (per-phase) Material Models**

- Linear (Thermo) Elasticity
  - Isotropic / Transversely isotropic /Orthotropic / Anisotropic
- Linear Viscoelasticity
- (Thermo) Elastoplasticity
  - J2 Plasticity
    - Isotropic hardening
      - Power / Exponential / Exponential linear laws
    - Kinematic hardening (linear with restoration)
  - Drucker-Prager
    - Pressure-dependent elastoplasticity
- Elastoplasticity with Damage: Lemaître-Chaboche
- (Thermo) Elasto-Viscoplasticity
  - Norton / Power / Prandtl laws
- Viscoelasticity-Viscoplasticity
- Hyperelasticity (finite strain)
  - Neo-Hookean / Mooney-Rivlin / Ogden / Swanson / Storakers (compressible foams)
- Elasto-viscoplasticity (finite strain): Leonov-EGP
- Thermal & electrical conductivity: Ohm & Fourier

**Microstructure Morphology**

- Multiple reinforcement phases
- Multi-layer microstructure
- Ellipsoidal reinforcements (fillers, fibers, platelets)
- Aspect ratio distribution
- General orientation (fixed, random, 2nd order orientation tensor)
- Void inclusions
- Coated inclusions with relative or absolute thickness
- Deformable, quasi-rigid or rigid inclusions

**Homogenization Methods**

- Mori-Tanaka
- Interpolative double inclusion
- 1st and 2nd order homogenization schemes
- Multi-step, multi-level homogenization methods

**Failure Indicators**

- Applied at micro and/or macro scale, or on pseudo-grains using the FPGF model (First Pseudo-Grain Failure model)
- Failure models: Max stress and Max strain, Tsai–Hill 2D & 3D, Azzi-Tsai–Hill 2D, Tsai–Wu 2D & 3D, Hashin–Rotem 2D, Hashin 2D & 3D
- Strain rate dependent failure criteria
- Failure criteria on Leonov-EGP & hyperelastic material models

**Loading**

- Monotonic, cyclic or user-defined history loading
- Multi-axial stress or strain, General 2D & 3D
- Mechanical and thermo-mechanical
- Prediction of thermal & electrical conductivities
- Loading definition from structural FEA results, i.e. Abaqus ODB file

**Isotropic Extraction Methods**

- General
- Spectral

**More Functionalities**

- Prediction of orthotropic engineering constants
- User defined outputs
- Interoperability with Digimat-FE and Digimat-MX
- Handling of encrypted material files
NEW IN Digimat 4.4.1

- RVE generation — periodic boundary conditions for UD composites
- Interfaces — support of ANSYS v14.5
- Microstructure — load layer definition from generic .csv formatted files

MAIN CAPABILITIES

Definition of Composite Constituents

- Inclusion shapes: Spheroid, Platelet, Ellipsoid, Cylinder (capped or not), Prism / Icosahedrons, Any custom shape imported from a geometry file (.step)
- Inter-operability with Digimat-MF and Digimat-MX for material definition

Microstructure Definition

- Microstructure morphology definition:
  - Volume / Mass content
  - Multiple inclusion shapes
  - General orientation definition (fixed, random, 2nd order orientation tensor)
  - Fiber length with access to size distribution
  - Coating
  - Clustering of inclusions
- Filler / Matrix debonding
- Multi-layer microstructure

RVE Generation

- RVE microstructure generation with real-time preview & animation process
- Maximum packing algorithm
- 3D & 2D RVES

RVE Analysis

- Monotonic / Cyclic / User-defined history loadings
- Multi-axial stress or strain, General 2D & 3D
- Mechanical and thermo-mechanical
- Computation of the percolation threshold
- Prediction of thermal and electrical conductivities
- Loading definition from structural FEA, i.e. Abaqus ODB file
- Export of RVE geometry in common formats: STEP, IGES, BREP
- Export geometry and model definition to Abaqus/CAE and ANSYS Workbench

FE Meshing

- Automatic adaptive mesh seeding and iterative mesh generation in Abaqus/CAE and ANSYS Workbench
- RVE meshing embedded beam elements, straight or curved

FE Solver & Post-Processing

- FE solution: Abaqus/Standard, Ansys Workbench
- Post-processing: Digimat-FE, Abaqus/CAE, Ansys Workbench
**Main Capabilities**

- **Material Database**
  - Gives access to:
    - Experimental data (tensile)
    - Digimat material / analysis files for homogeneous / composite materials
  - Data available under various conditions:
    - Temperature, relative humidity, strain rates & loading angles
  - Import, Filter & Reverse Engineering tools

- **Parametric Identification**
  - Identify material models’ parameters based on the homogeneous material responses
  - Can be done on one or several curves at the same time

- **Reverse Engineering**
  - Can be done on one or several curves at the same time:
    - Various loading angles, strain rates & / or temperatures
    - At homogeneous and macroscopic level
  - Material models that can be reverse-engineered:
    - (Thermo) Elastic
    - Viscoelastic (2 RE techniques available)
    - (Thermo) Elasto-Viscoplastic
  - Other features that can be reverse-engineered:
    - Aspect ratio of inclusion phase
    - Strength parameters of failure indicators
    - Thermal dependencies of thermo-mechanical material parameters
  - Multi-layer microstructures are supported

- **Encryption**
  - Material files can be encrypted for confidentiality purposes (available in MX+)
  - Encrypted files can be used in Digimat-MF and Digimat-CAE, the material parameters being hidden
  - Encrypted material files can be attributed an expiration date (available in MX+)

- **Interaction between Digimat-MX and other products**
  - Interoperability with Digimat-MF, Digimat-FE & Digimat-CAE

**NEW IN Digimat 4.4.1**

- **Public data** — new data from material suppliers
  - Evonik Industries, Sabic
- **Generic materials** — provided by e-Xstream
  - (Thermo-)Elastic, (Thermo-)Elastoplastic models
- **Easier import of engineering data** — GUI tool
  - Direct input of elastic moduli
  - Copy/paste from Excel (general tabular data)
- **Reverse engineering** — GUI tool
  - Easier workflow for non-material experts

**Material eXchange platform used to prepare, store, retrieve and securely exchange Digimat material models between material suppliers and end-users under full protection of the Intellectual Property.**

Prepare, store and eXchange material models under protection of your intellectual knowledge!
NEW IN Digimat 4.4.1

- **Linear solution** — entry solution to Digimat-CAE
  - Coupled analyses with (thermo-)elastic materials
  - Based on direct engineering, generic models or .daf files
  - No license blocked during coupled analysis runs

- **Micro solution** — speed-up
  - 10—20% gain in CPU for shell models

- **Hybrid solution** — speed-up, memory & failure
  - ~30—50% gain in CPU
  - ~40% decrease in memory usage
  - Strain based failure
  - Strain rate dependent failure

- **Interface(s) to FEA**
  - MSC Nastran SDL400
  - Plug-in for Marc Mentat
  - Support of ANSYS v14.5, Marc 2012(Win 64bit), MSC Nastran 2013

MAIN CAPABILITIES

**Digimat-CAE/Process**
- Takes into account:
  - Fiber orientation
  - Residual stresses
  - Residual temperatures
  - Weldlines
- **FEA solver types:**
  - Explicit
  - Implicit
- **Element types:**
  - Shell: 1st & 2nd order Triangles & Quadrangles
  - 3D: Tetrahedron, Hexahedron, 1st & 2nd order, reduced and fully integrated
  (For 2nd order elements, each individual integration point can be assigned fiber orientation by using the DIGIMAT orientation file format)
- **Micromechanical Material Model**:
  - Linear
  - Nonlinear
  - Rate dependent
  - Thermo dependent
  - Finite strain
- **Coupled interfaces with:**
  - 3D Timon
  - Autodesk Moldflow Insight
  - Moldex3D
  - REM3D
  - SigmaSoft
  - Simulayt
- **Plug-ins in:**
  - Abaqus/CAE
  - ANSYS Workbench
  - HyperMesh

**Digimat-CAE/Structural**
- **Strong coupling interfaces to FEA:**
  - Abaqus/CAE, Standard & Explicit
  - ANSYS Mechanical
  - LS-DYNA, Implicit & Explicit
  - Marc
  - Optistruct
  - PAM-CRASH
  - RADIOSS
  - SAMCEF-Mecano
- **Weak coupling available to all FEA solvers for thermo-elastic material properties**

**Interface(s) to fatigue**
- nCode DesignLife: support of 2D & 3D analyses

**Interface(s) to injection molding**
- SIMPOE (via MAP)
- Moldex3D / 2D mesh: fiber orientations
- Moldex3D / 3D mesh: temperatures, weld lines & initial stresses

**Interface(s) to (injection-)compression molding**
- Moldflow & Moldex3D (3D analyses)

**Automated procedures**
- Mesh superposition by gravity center & axes of inertia
- 3D Mapping

Digimat linear and nonlinear interfaces to major process and structural FEA software to enable multi-scale analyses of composite materials and structures.

Bridge the gap between processing and FEA by using Digimat material models in your structural design!
Shell & 3D mapping software used to transfer fiber orientation, residual stresses and temperatures between dissimilar injection molding and structural FEA meshes.

Use the optimal mesh and increase the accuracy and efficiency of your FE analyses!

**NEW IN Digimat 4.4.1**

- **Automated Procedures**
  - Measurement of distance & angle between picked nodes
  - Mesh superposition by gravity center & axes of inertia
- **Cross Mapping**
  - From 3D volume to 2D shell meshes
- **Meshe**
  - Nastran
  - Samcef: support of quadratic elements
- **Orientation Formats**
  - SIMPOE
- **Fiber Related Post Processing**
  - Visualization of material properties

**MAIN CAPABILITIES**

**Data Types Managed by Digimat-MAP**

- Fiber orientation tensors
- Residual stresses
- Temperature field
- Weld Lines

**Supported Elements**

- **Donor mesh:**
  - Tetrahedron or triangular shell elements
  - Hexahedron and wedge elements
- **Receiver mesh:**
  - Tetrahedron or triangular shell elements
  - Hexahedron or quadrangular shell elements
  - Wedge elements

**Data Post-Processing**

- Contour or vector plots
- Display tensorial fields using ellipsoids
- Synchronized display of donor and receiving meshes
- Through-the-thickness orientation or temperature plot for shell elements
- Cut plane on 3D meshes

**Error Indicators**

- Global & local error indicators to validate mapping quality

**Shell & 3D Mapping**

- From midplane to multi-layered shell
- Between Continuum 3D elements
- Across the shell thickness

**Supported File Formats**

- **Meshes:**
  - Abaqus
  - ANSYS
  - Ideas
  - LS-DYNA
  - PAM-CRASH
  - Patran
  - RADIOSS
  - REM3D
  - SAMCEF
  - 3D Timon
- **Data:**
  - DIGIMAT
  - Moldex3D
  - Moldflow Mid-Plane
  - Moldflow 3D
  - REM3D
  - SigmaSoft
  - 3D Timon

**Donor-Receiver Positioning**

- Scaling, Translation, Rotation, Superposition

**Visualizations**

- Mapping of midplane fiber orientation tensors
- Fiber orientation using the ellipsoid display
- Vector plot of fiber orientations on a 3D mesh
- Global error indicator (histogram plot)
Main Capabilities

Skin Definition
- Pile up:
  - Symmetric
  - Anti-symmetric
- Material properties:
  - Orthotropic elastic properties of the ply
  - Ply orientation
- Resin/Fibers:
  - Isotropic elastic properties of the resin and fibers
  - Fiber weight fraction, length and orientation

The equivalent, homogenous, properties of the skins are computed using micromechanics.

FEA Model
- Automatic mesh generation following selected mesh refinement:
  - Coarse
  - Average
  - Fine
- Loading:
  - Three-point bending
  - Four-point bending
  - In-plane shear

Customized positions and amplitudes for loading points and fixations.

Core Definition
- Honeycomb: honeycomb properties are computed using micromechanical models based on the cell geometry and the bulk properties
- Foam

Post-processing
Integrated post-processing including 3D and through-thickness views of stresses, strains and failure indicators.

Failure Indicators
- Core:
  - Maximum stress (comprehensive, shear)
- Skin:
  - Maximum stress
  - Tsai-Wu
  - Tsai-Hill
  - Azzi-Tsai-Hill

Automatic Report Generation (html)
Automatic Generation and Solving of the FEA Model using a Built-in FEA Solver
e-Xstream engineering develops and commercializes Digimat suite of software, a state of the art multi-scale material modeling technology that speeds up the development of optimal composite materials and parts for material suppliers and end users in the automotive, aerospace, consumer goods and industrial equipment industries. e-Xstream provides material scientists and simulation engineers with innovative material modeling tools to allow them to accurately predict the micromechanical behavior of reinforced materials and perform accurate design of composite structures (PMC, RMC, MMC, nanocomposites, honeycomb sandwich panels, ...). An optimal design of composite parts is then materialized into lighter, cheaper and higher quality products brought faster to the market.

Digimat. The nonlinear multi-scale material & structure modeling platform, is an efficient predictive tool that helps our customers designing and manufacturing innovative and optimal composite materials and parts fast and cost efficiently. With major customers in Europe, America and Asia, we have added to our deep expertise in numerical simulation the business understanding of a large variety of materials such as reinforced plastics, rubber, hard metals, nanocomposites and honeycomb sandwich panels used across the automotive, aerospace, consumer and industrial equipments industries.