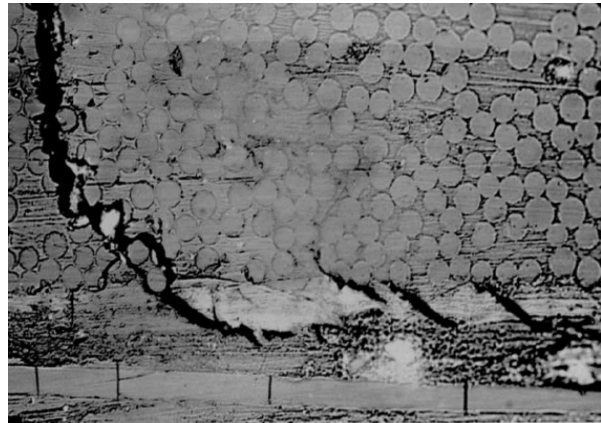


## DocMASE Project Proposal 2014-01

Project Title	<b>Failure of laminated structures due to interlayer delaminations</b>
Main University and Advisor	EEIGM – University of Lorraine (France) Prof. Zoubir Ayadi
Second University and Advisor	Lulea University of Technology (Sweden) Prof. Janis Varna
Associated Partner(s) (if applicable)	
Project Description (with <b>image</b> , if applicable)	<p>The first mode of damage in laminated composite structures is usually intralaminar cracks crossing the whole thickness of the layer and propagating along the fibers in this layer. At the interface with the next layer the crack stops. The high shear stresses and out-of-plane stresses lead to the interface delamination, see Fig. The delaminated zone is usually very small, much less than the layer thickness. Nevertheless in the following service life the composite is subjected to various types of loading including cyclic and out-of-plane loading. In result the delamination zone growth reducing the macroscopic thermo-elastic properties.</p>  <p>Finally the delamination leads to the loss of the structural integrity thus significantly decreasing the fatigue life. The objective of the project is to study the mechanisms of the initiation of the delamination as dependent on geometrical and stiffness parameters and its effect on the composite structure's stiffness. Experimental observations (microscopy, SEM) will be complemented by speckle full displacement field measurements and compared with theoretical predictions using finite elements. The growth of the debonded zone during loading will be analyzed using FEM with cohesive elements and fracture mechanics, finding recommendations for most delamination resistant designs.</p>
Previous Publications	<p>Varna J. and L.A. Berglund, "<i>Thermo-Elastic Properties of Composite Laminates with transverse cracks</i>," Journal of Composites Technology &amp; Research, vol 16, No1 January 1994, 77-87.</p> <p>Lundmark P. and Varna J., "<i>Constitutive Relationships for Laminates with Ply Cracks in In-plane Loading</i>", International Journal of Damage Mechanics (2005); 14 (3); 235-261.</p> <p>Farge L. Varna J. and Ayadi Z.: Damage characterization of a cross-ply carbon fiber/epoxy laminate by an optical measurement of the displacement field, Composites Science and technology, (2010), vol.70,p94-101.</p>
References	<p>Berthelot J-M. Transverse cracking and Delamination in Cross-Ply Glass-Fiber and Carbon-Fiber Reinforced Plastic Laminates: Static and Fatigue Loading. Appl Mech Rev 2003; 56(1): 111-147.</p> <p>Takeda Nobuo, Shinji Ogihara, Akira Kobayashi, Microscopic fatigue damage progress in CFRP cross-ply laminates, Composites, 26, 1995, 859-867.</p> <p>Kashtalyan M., Costas Soutis, Analysis of composite laminates with intra- and interlaminar damage, Progress in Aerospace Sciences, 41 (2005) 152-173.</p>
Requirements of the candidates / Requirements during the doctoral programme (courses, seminars, etc.)	Following the Swedish requirements with respect to the credit points for courses, the student will have to take courses in the amount of 60 ECTS which correspond to one additional year of studies (3+1). The fourth year will be financed by Lulea University of Technology. 15 ECTS of the 60 will be obtained in common courses, workshops and summer schools organized by DocMASE