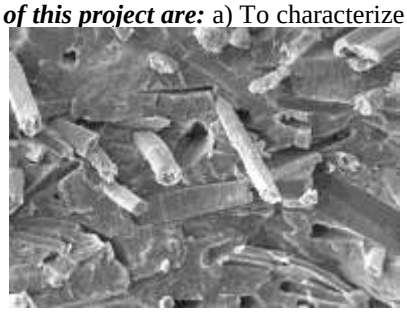
Project Proposal for 2011 DocMASE Candidates

Project Title	***Short natural fiber composites: Mechanisms and Simulation of deformation and failure***
Main University and Advisor	**Saarland University (UdS)** (Saarbrücken, GERMANY) Prof. Markus STOMMEL
Second Univ. and Advisor	**Luleå University of Technology (LTU)** (Luleå, SWEDEN) Prof. Janis VARNA
Associated Partner(s)	**Swerea, SICOMP** (Piteå, SWEDEN)
Project Description	Increasing environmental awareness and growing social interest in reducing dependence on non-renewable plastics have resulted in a search for competitive bio-based replacement materials. Composites based on thermoplastic biopolymers (lignin, starch, PLA) reinforced with natural fibers (wood or agrofibers such as flax, hemp, kenaf, jute) are increasingly used as engineering materials in various industries. This requires reliable technical understanding of the deformation and failure of these materials. Typical manufacturing of these materials is by injection molding. Fibers are usually 1-2 mm long before processing and can be considered long but during processing they are partially damaged and the average fiber length is reduced to an unknown fiber length distribution function. Since the fibers are shorter than the composite thickness the fiber orientation distribution is generally 3D with some preferred orientation resulting from injection (as illustrated in Fig. 1). Natural fiber composites offer a complex mechanical behavior that makes engineering of technical parts challenging: they show microdamage related elastic properties reduction, parallel to nonlinear viscoelastic and viscoplastic behavior. This is related to the similar behaviours of both constituents in these composites. Another feature requiring investigation is the dependence of mechanical behaviour on moisture and temperature. ***The goals of this project are:*** a) To characterize the inelastic and time dependent behavior of natural fibers and resins and describe the behavior with material models;  Fig. 1. Fracture surface of flax fiber reinforced polypropylene composite /LTU/ b) To characterize the resulting natural fiber orientation and length distribution functions dependent upon typical processing conditions; c) To compare measured fiber orientations to simulated orientations by means of injection molding process simulations; d) To experimentally characterize the macroproperties of composites and develop empirical material models accounting for damage, viscoelasticity and visco-plasticity. e) To develop micromechanism-based mechanical models to describe mechanical and failure properties of composites on a macro level. LTU tasks: mechanical testing and empirical model development on micro- and macroscales. UdS tasks: micromechanic models accounting for (non)linear viscoelasticity, viscoplasticity and damage. Models will be extended towards fiber geometry and fiber orientation distribution functions. First three PhD years: 70% of time working in Germany, 30% in Sweden. Last (4^{th}) year: 100% financed by Polymerteknik, LTU, and about 70% of time working in Sweden.
References and Previous Publications	[1] Nordin L.-O., Varna J., "Nonlinear viscoplastic and nonlinear viscoelastic material model for paper fiber composites in compression", Composites Part A, 37 (2006), 344-355. [2] Marklund E., J. Varna, L. Wallström, Nonlinear viscoelasticity and viscoplasticity of flax/polypropylene composites, JEMT, (2006), vol. 128, 527-536. [3] Marklund E., J. Eitzenberger, J. Varna, Nonlinear viscoelastic viscoplastic material model including stiffness degradation for hemp/lignin composites, Composites sci-ence and technology, 68 (2008), 2156-2162. [4] Sparnins E., Pupurs A., Varna J., Joffe R., Nättinen K., Lampinen J., The moisture and temperature effect on mechanical performance of flax/starch composites in quasi-static tension. Polymer Composites, 2010, submitted. [5] Stommel, M., Kaiser, J.-M., Inverse Determination of Modeling Parameters to Consider Inhomogeneities of Semi-Crystalline Thermoplastics in Structure Simulations, Macromolecular Symposia, 2010, submitted. [6] Stommel, M., Naumann, T., Modelling the Load and Temperature Dependent Long Term Behaviour of PS and POM, Proceedings of the International Conference on Advances in Mechanical Engineering and Mechanics, Tunisia, 2010, accepted. [7] Stommel, M., Naumann, T., Simulation des Langzeitverhaltens von Kunststoffen, VDI-Berichte, 2010.