

TABLE OF CONTENTS

| | |
|---|----|
| 1. INTRODUCTION | 1 |
| 1.1 Material Combinations | 2 |
| 1.2 Microstructure | 4 |
| 1.3 Micromechanical Investigations | 6 |
| 2. SYMMETRY CONDITIONS IN MATERIALS | 8 |
| 2.1 Geometric Types of Symmetry | 8 |
| 2.2 Thermal Expansion Behaviour | 9 |
| 2.3 Elastic Behaviour | 11 |
| 3. MEANFIELD MODELS | 14 |
| 3.1 Self Consistent Methods | 15 |
| 3.2 Approximations for the Self Consistent Solution | 18 |
| 4. PERIODIC MICROFIELD MODELS | 21 |
| 4.1 3/D Models for Particle Reinforcement | 22 |
| 4.2 3/D Models for Aligned Short Fiber Reinforcement | 28 |
| 4.3 Axisymmetric Models | 28 |
| 4.3.1 <i>Periodic Arrangements</i> | 30 |
| 4.3.2 <i>Perturbation of Periodicity</i> | 33 |
| 4.4 Plane Models | 35 |
| 4.5 Material Model | 35 |
| 4.6 Finite Element Meshes | 39 |
| 5. TENSILE LOADING | 40 |
| 5.1 Definition of a Damage Indicator | 40 |
| 5.2 Particle Reinforced Aluminum | 41 |
| 5.2.1 <i>Cubic Arrangements with Spherical Inclusions</i> | 41 |
| 5.2.2 <i>Different Inclusion Shapes in Cubic Arrangements</i> | 48 |
| 5.2.3 <i>Axisymmetric Models</i> | 53 |
| 5.2.4 <i>Plane Models</i> | 54 |
| 5.2.5 <i>Influence of Thermal Residual Stresses</i> | 55 |
| 5.2.6 <i>Damage Evolution</i> | 58 |

| | | |
|-------|---|-----|
| 5.3 | Aligned Short Fiber Reinforced Aluminum | 61 |
| 5.3.1 | <i>Comparison of Staggered and Unstaggered Models</i> | 61 |
| 5.3.2 | <i>Influence of Thermal Residual Stresses</i> | 67 |
| 5.3.3 | <i>Damage Evolution</i> | 73 |
| 5.3.4 | <i>Perturbed Periodic Models</i> | 74 |
| 5.3.5 | <i>Cyclic Tensile Loading</i> | 80 |
| 6. | THERMAL LOADING | 81 |
| 6.1 | Particle Reinforced Aluminum | 81 |
| 6.1.1 | <i>Cubic Arrangements</i> | 81 |
| 6.1.2 | <i>Axisymmetric and Plane Models</i> | 86 |
| 6.2 | Aligned Short Fiber Reinforced Aluminum | 87 |
| 6.2.1 | <i>Comparison of Staggered and Unstaggered Models</i> | 87 |
| 6.2.2 | <i>Influence of Fiber Volume Fraction</i> | 97 |
| 6.2.3 | <i>Influence of Thermal Residual Stresses</i> | 102 |
| 6.2.4 | <i>Perturbed Periodic Models</i> | 103 |
| 6.2.5 | <i>Cyclic Thermal Loading</i> | 109 |
| 7. | INTERFACE STRESSES | 110 |
| 7.1 | Particle Reinforced Aluminum | 110 |
| 7.2 | Aligned Short Fiber Reinforced Aluminum | 113 |
| 8. | CONCLUSIONS | 114 |
| 9. | REFERENCES | 115 |