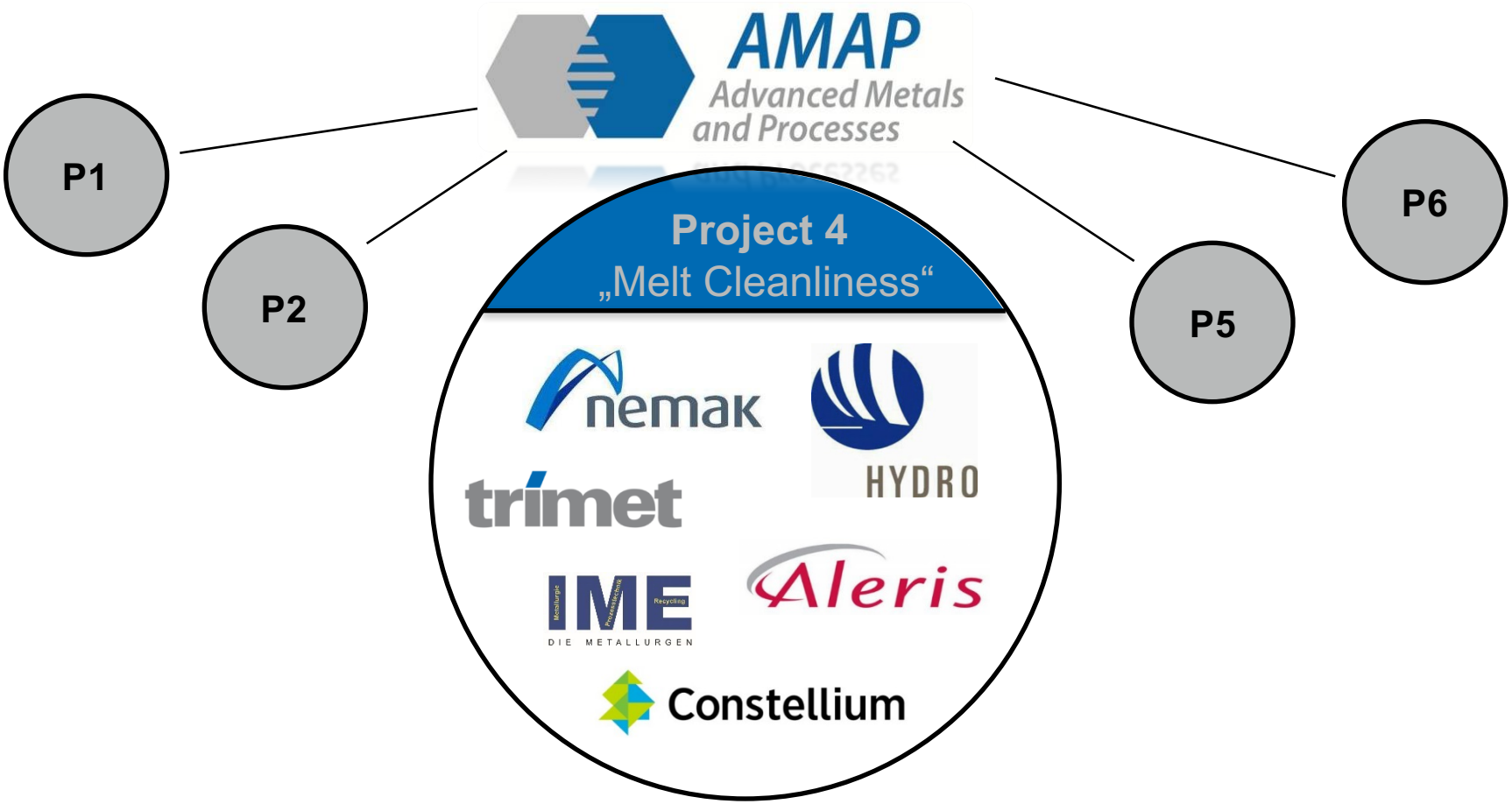
AMAP P4 „Melt Cleanliness“:

Building a multi-partner network in the area of melt treatment

AMAP‘s 3rd Anniversary
21st January, 2016
Ford Research and Innovation Center Aachen

Dr. M. Badowski (Hydro Aluminium Rolled Products GmbH
+ AMAP P4 Team
+ Dr. S. Tewes (Nemak Europe GmbH) – Project Manager 2013 – 2015
+ Dr. J. Morscheiser (Aleris Rolled Products GmbH) – Project Manager since 2015

AMAP P4 Introduction



- Goal 1st Project Phase (3-years): Demonstrator for Particle Monitoring in Liquid Al
- Presentation scope: Evolution of the AMAP P4 Team and Management Approach

Phase 1 (2013) – Competence & Trust

- Start AMAP P4: Facing challenges
  - New colleagues with varying expertise & background (technical/cultural)
  - Different commitment & ambition
  - Complexity of roles & responsibilities
  - Contract construe in progress

- Task 1: Competence

  We took substantial time to adjust the project activities:
  - Balanced to the expectation of the partners
  - Using the equipment and expertise provided by the partners
  - Identification of gaps to reach the overall project goal

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- Start AMAP P4: Facing challenges
  - New colleagues with varying expertise & background (technical/cultural)
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  - Complexity of roles & responsibilities
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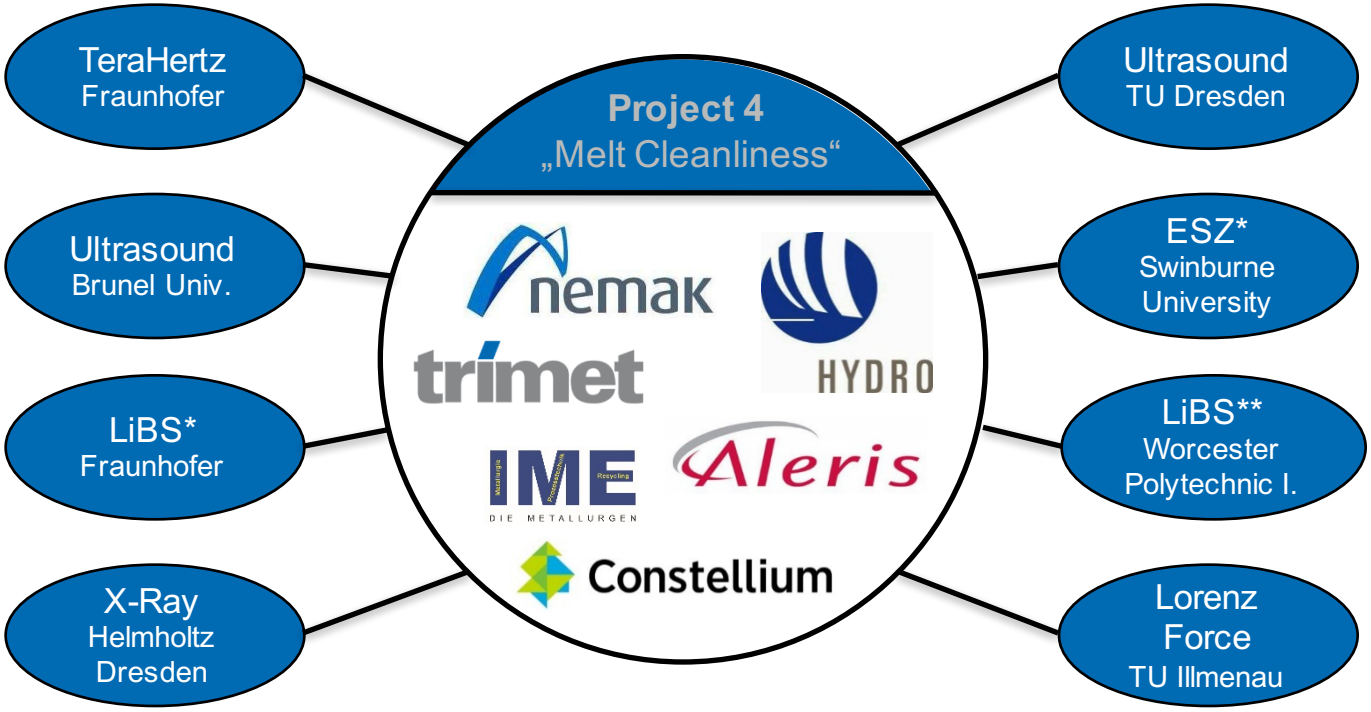
- Task 2: Trust
  - Common agreed & detailed project agreement
  - Small project activities
  - Group project activities

AMAP Advanced Metals and Processes

- Establishing external contact points

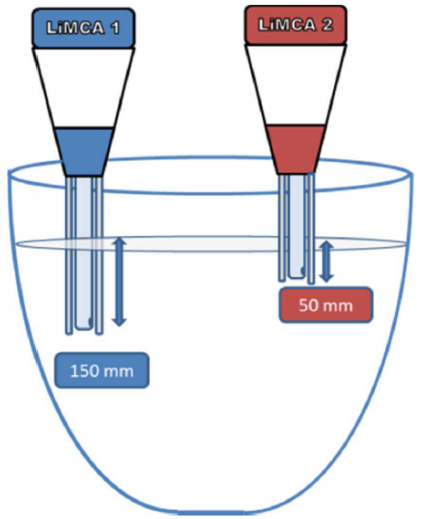


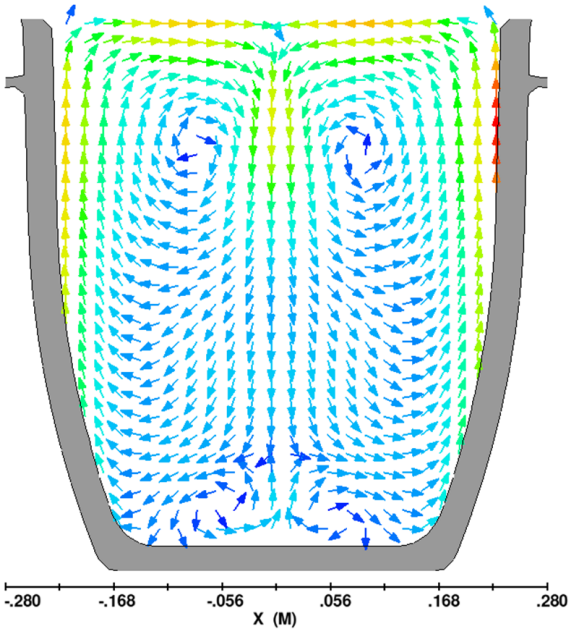
- Goal: Identifying of **feasible technical approaches** and **world-class expertise**

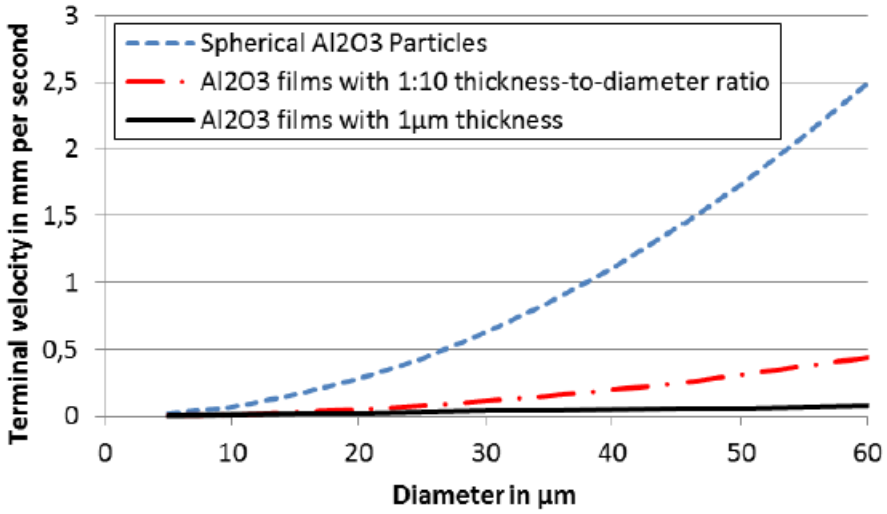
* ESZ: Electrical Sensing Zone
** LiBS: Laser Induced Breakdown Spectroscopy

Phase 2 (2013+2014): The „Open“ Approach

- Establishing AMAP P4 in the research world:
  - Project activity (IP uncritical): **Settling & Agglomeration**
    - Analytical + numerical modelling
    - New (LiMCA) particle monitoring procedure
    - Lab scale studies

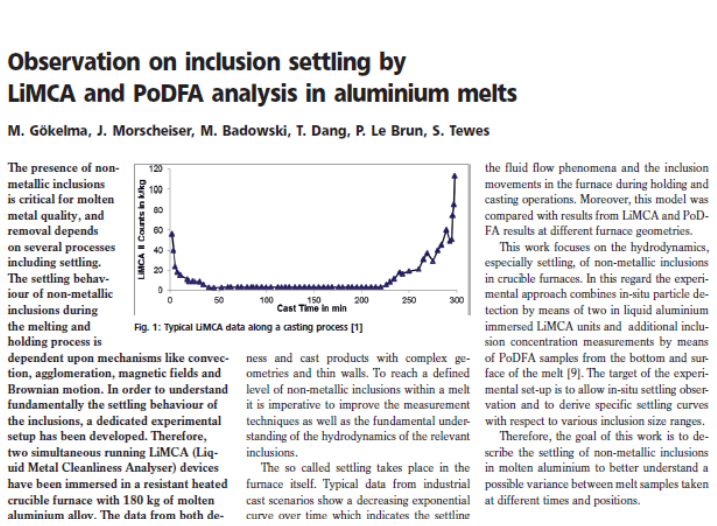






Phase 2 (2013+2014): The „Open“ Approach

- Establishing AMAP P4 in the research world:
  - Project activity (IP uncritical): **Settling & Agglomeration**
    - Analytical + numerical modelling
    - New (LiMCA) particle monitoring procedure
    - Lab scale studies
  - Extensive publication
    - 4 Journal papers
    - 5 presentations on international conferences



Observation on inclusion settling by LiMCA and PoDFA analysis in aluminium melts

M. Gökelma, J. Morscheiser, M. Badowski, T. Dang, P. Le Brun, S. Tewes

The presence of non-metallic inclusions is critical for molten metal quality, and removal depends on several processes including settling. The settling behaviour of non-metallic inclusions during the melting and holding process is dependent upon mechanisms like convection, agglomeration, magnetic fields and Brownian motion. In order to understand fundamentally the settling behaviour of the inclusions, a dedicated experimental setup has been developed. Therefore, two simultaneous running LiMCA (Liquid Metal Cleanliness Analyser) devices have been immersed in a resistant heated crucible furnace with 180 kg of molten aluminium alloy. The data from both devices and cast products with complex geometries and thin walls. To reach a defined level of non-metallic inclusions within a melt it is imperative to improve the measurement techniques as well as the fundamental understanding of the hydrodynamics of the relevant inclusions.

Fig. 1: Typical LiMCA data along a casting process [1]

The so called settling takes place in the furnace itself. Typical data from industrial cast scenarios show a decreasing exponential curve over time which indicates the settling the fluid flow phenomena and the inclusion movements in the furnace during holding and casting operations. Moreover, this model was compared with results from LiMCA and PoDFA results at different furnace geometries.

This work focuses on the hydrodynamics, especially settling, of non-metallic inclusions in crucible furnaces. In this regard the experimental approach combines in-situ particle detection by means of two in liquid aluminium immersed LiMCA units and additional inclusion concentration measurements by means of PoDFA samples from the bottom and surface of the melt [9]. The target of the experimental set-up is to allow in-situ settling observation and to derive specific settling curves with respect to various inclusion size ranges.

Therefore, the goal of this work is to describe the settling of non-metallic inclusions in molten aluminium to better understand a possible variance between melt samples taken at different times and positions.

Light Metals 2015
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TMS (The Minerals, Metals & Materials Society), 2015

STUDY OF PARTICLE SETTLING AND SEDIMENTATION IN A CRUCIBLE FURNACE

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Keywords: Settling, Sedimentation, Stokes' law, LiMCA, Inclusions

Abstract

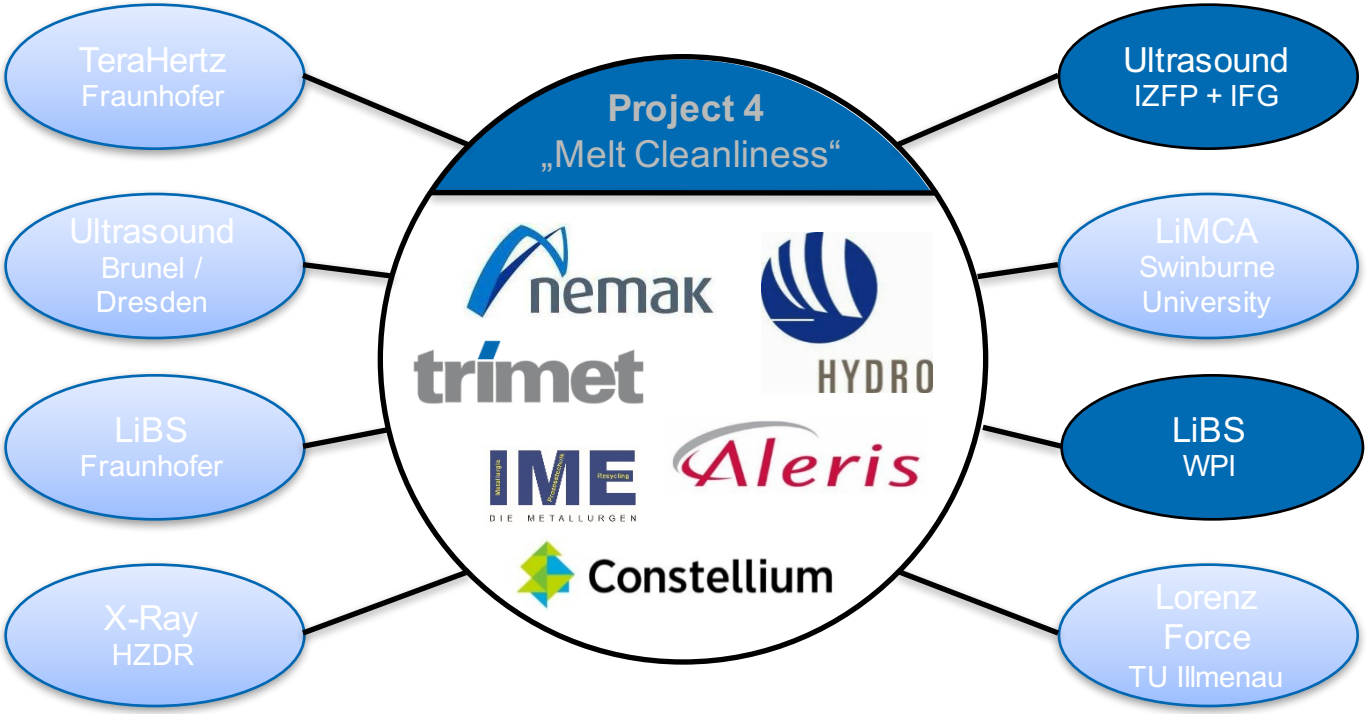
Particle settling and stratification in aluminium processing operations are of importance for cast house performance and product quality as they influence important factors such as furnace cleaning frequency, and design of launder troughs and inline equipment.

Analytical analyses of settling generally refer to Stokes' law describing the motion of a solid sphere in a liquid but neglect the dominating factor of thermal convection. A new option to monitor particle concentrations at different melt depths based on LiMCA technology was utilized to study particle settling within AMAP, the Open Innovation Research Cluster for Non-Ferrous Metals at RWTH Aachen University.

This paper reports the initial results obtained with the new LiMCA method in trials in a laboratory crucible furnace. The results are analysed with respect to the influence of particle size on settling kinetics and stratification and are compared to the behavior in furnaces in detail to further improve the melt quality and finally the cast house products.

The settling of non-metallic inclusions has been studied in detail by LiMCA monitoring at the furnace exit of stationary and tiltable furnaces in operation [2],[4] and it has been proven to improve the melt quality continuously over several hours as long as no stirring disturbs the process. Otherwise, the LiMCA monitoring in operation generally misses the initial period of the settling curve as it starts after the applied settling time and intermediate stirring, like shown in Figure 1 was used in test charges to evaluate in detail the initial settling kinetic after an homogenization of the melt [2].

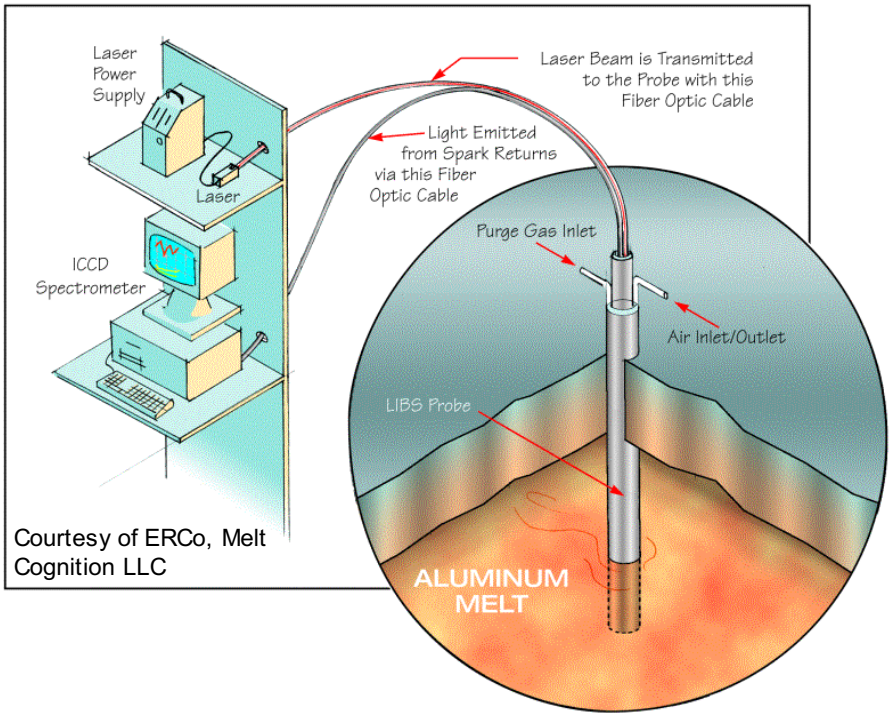
- Establishing external AMAP network



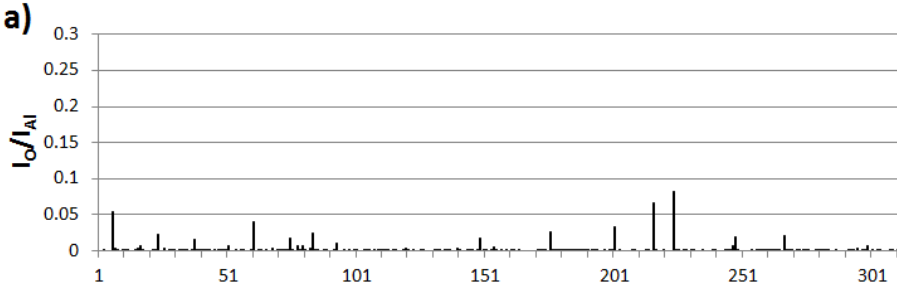
- Goal: Utilizing AMAP P4 **network expertise**
  - Strong bound to external partner
  - Dedicated team and contact point of AMAP P4

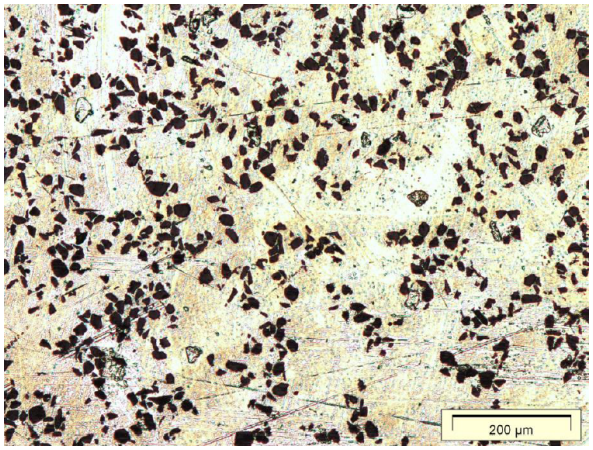
AMAP Advanced Metals and Processes

a) LiBS (Laser Induced Breakdown Spectroscopy) in cooperation with Worchester Polytechnic Institute (Prof. D. Apelian)



Courtesy of ERCo, Melt Cognition LLC





Al_2O_3 Master alloy

- Status: Laboratory Prototype Evaluation

AMAP Advanced Metals and Processes

a) Ultrasound in cooperation with RWTH Aachen & Fraunhofer IZFP (Institut für zerstörungsfreie Prüfverfahren)

- Activity overview:
  - Old particles detection approach (>50 years)
  - Obstacle: Monitoring Reliability
    - Operation
    - Metallurgy
  - Developed Solutions:
    - Transducer coupling
    - Guide rod materials
    - Wetting procedure

- Status: Laboratory scale testing

Summary

- Challenges:
  - Setting up a suitable frame
  - Team building of a group with different background
  - Extension out of the AMAP box
- AMAP is a fantastic platform:
  - Extended access to equipment & expertise
  - Creating new idea and approaches
  - Overcoming company barriers
- Pre-requisites:
  - Commitment & substantial participation
  - Openness to changes
- Way forward for AMAP P4:
  - Prolongation for 1 year with identical scope
  - Prototype development and validation