This paper reviews comprehensive development of Chinese magnesium industry in 2014, which mainly introduces improvements in basic and key manufacturing sections and operation platform of the industrial chain such as smelting, processing, market promotion, etc. These improvements include development of energy saving and emission reduction, technological innovation, structural adjustment, industrial upgrading and etc.

Meanwhile, according to the general layout of Chinese nonferrous metals industry for the next period, the paper preliminary describes development concepts of Chinese magnesium industry for 2015 and the following three to five years.

The report is consisted with 2 parts. In the first part of it, I will report about updated information about the Magnesium market situation based on the analysis on Import & Export statistics & our own investigation on domestic production data.

In the second part, you can look through current trends for developments categorized by following key words;

1) Projects of Japan Magnesium Association (eg. Automobile, Train etc.)
2) Material Level (eg. Die-casting, Extrusion, rolling etc.)
3) Application (eg. Transportation equipment, Nursing + Medical, Electric machines, Batteries, Acoustic equipment etc.)
4) Recycling
5) Smelting projects

With above several directions of developments, Japanese market is expected to increase its demands for pure magnesium ingots & Magnesium alloy in coming years.
Market Opportunity In The Automotive Sector
Tim Skszek, Magna International

Regulation requirements such as the 2020 CAFE (Corporate Average Fuel Economy) standard, CO2 compliance and consumer demand to address the environmental impact associated with transportation are pushing auto manufacturers worldwide to increase fuel economy through incorporation of lightweight materials in newly-designed vehicle structures. The migration of material selection from steel-intensive designs to aluminum-intensive vehicles is currently taking place. Recent advances in magnesium primary production, manufacturing processes, alloy development, multimaterial joining and corrosion mitigation have enabled new product applications, further reducing vehicle mass. In order to move beyond niche low volume applications, issues relative to global material availability, manufacturing infrastructure and cost parity with aluminum need be addressed. This paper will focus on the emerging automotive application of magnesium.

Development Of A Thin Walled Magnesium Side Door Inner Panel For Automobiles
John Jekl, Meridian Lightweight Technologies

Cast magnesium side door inner panels can provide a good compromise between weight, functional, manufacturing and economical requirements. However, several challenges exist including casting technology for thin-walled part design, multi-material incompatibility and low strength. We have initiated a project, funded by the US Department of Energy, to design and develop a lightweight frame-under-glass door having a thin walled magnesium inner panel. This type of development project is the first of its kind within North America. Phase I of the project is now complete and the 2.0mm magnesium design, through casting process enablers, has met or exceeded all stiffness requirements, with significant mass reduction and part consolidation. In addition, a corrosion mitigation strategy has been established using industry accepted galvanic isolation methods and coating technologies.

Die-Cast Magnesium Field Corrosion Correlation With Accelerated Laboratory Corrosion Testing
Jon Weiler, Meridian Lightweight Technologies

Corrosion of die-cast magnesium alloys is not well understood in the automotive industry and limits the use of these materials in automotive applications. Beginning in 2004, magnesium die-castings have been used for radiator support / front end carrier/bolster applications by several OEMs. Sufficient field use has passed to investigate
these components from a corrosion perspective and compare with accelerated laboratory corrosion testing. In this study, MRS (Magnesium Radiator Support) components from 2004/5 F-150 vehicles exposed to a Nova Scotian climate were analyzed. General corrosion and galvanic corrosion at attaching points were examined and compared with results from die-cast magnesium alloy test plates exposed to:

1) accelerated laboratory corrosion tests ASTM B117 and Ford AGP-E
2) test plates affixed to the undercarriage of a passenger vehicle driven in Southwestern Ontario for 5 years
3) test plates exposed to Southwestern Ontario outdoor environment for 5 years.

Guidelines For The Market Competitiveness Of Sustainable Lightweight Design
By Magnesium Solution: A New Life Cycle Assessment Integrated Approach
Fabrizio D’Errico, Politecnico Di Milano, Department Of Mechanical Engineering

Recent changes to the Corporate Average Fuel Economy (CAFE) are driving automakers to seek more aggressive methods for fuel consumption reductions. In the long term, policy appears to focus on conversion of the dominant 20th century internal combustion engine (ICE) to a different engine that is partially or fully hydrocarbon-free. As the future of automotive propulsion is the subject of some debate, whatever the vehicle power source will be, weight reduction of the car is sure to be a key factor to meet energy saving requirements. The need to cut CO2 emissions by reducing fuel consumption on ICE vehicles may also benefit market penetration of hydrocarbon free battery powered vehicles. A major factor in this decision will be the success in reducing battery cost for travel ranges that will make electric vehicles attractive to consumers. For the next few years, the purchase price of a hybrid or fully electric car is expected to be several thousand Euros higher than the average price of the gas-fueled vehicle. It is worth noticing that price difference is largely due to the cost of battery (EU Commission targets a reduction in the cost of batteries by 6-8% annually together with improved chemistry and the economies of scale). To speed up the reduction in unitary mileage costs for full or hybrid electric vehicles lightweighting is again a key for success, however, a successful lightweight design will only be possible through a balanced solution that takes into account conflicting factors such as manufacturing costs, safety and crashworthiness, recycling and life cycle considerations.

Life cycle considerations, particularly, have led to a large number of Life Cycle Assessment (LCA) studies to determine the carbon footprint of using lightweight materials. Three key-factors for the assessment of environmental impact of lightweight design for conventional ICE vehicle are the materials substitution factor; the fuel-mass correlation factor; and the energy intensity and recycling factors of materials production.
In this work a material substitution scenario has been developed for assessing the net environmental impact of adoption of magnesium alloy panels instead of heavy steel panels, and competitive weight saving aluminum and CRFP panels. Clean-up strategies for the LCA magnesium model for the fossil-fueled automotive sector will also be discussed.

Temakplus – Development Of Industrial Production And Processing Technologies For Magnesium Sheet And Strip Materials
Jens Grigoleit, TU Bergakademie Freiberg, Institute Of Metal Forming

The article summarizes the findings of the research project TeMaKplus, which was focused on the development of innovative and economically improved production and processing technologies for wrought magnesium alloys. With a project consortium consisting of eleven industrial companies and two research institutes, the whole process chain was covered from the production of the sheet and strip material to the manufacturing of complex parts and new applications. The consortium of TeMaKplus encompasses partners who are specialized in the following technologies: Twin-roll casting and hot rolling of magnesium strip and sheet material, processing and forming of wrought magnesium alloys, joining, coating and surface protection as well as product development. The demonstrator parts developed involved automotive as well as non-automotive applications. The R&D work was financially supported by the German Federal Ministry of Education and Research and had a total budget of more than 7 Mio.€.

Current Research Activities On Production Technologies And Applications Of Magnesium Wrought Alloys In Germany
Jens Grigoleit, TU Bergakademie Freiberg, Institute Of Metal Forming

Based on current research activities involving the pilot plant for magnesium strip production in Freiberg, Germany, the article provides an overview on latest findings and perspectives in the fields of production, processing and application of magnesium wrought materials. The review includes the huge project initiatives SubSEEMag, LEIKA and SMiLE funded by the German Federal Government and concerning the production and application of enhanced sheet and strip materials as well as several other research projects including also the development of new production methods for magnesium wire materials via twin-roll casting and caliber rolling. The innovative approaches followed within the different projects are described as well as the major challenges and perspectives connected to them. In result, the article analyzes the current situation of
research and development in the field of magnesium wrought materials in Germany as well as it gives an outlook covering the next five to ten years.

**The Potential & Challenges For Automotive Sheet Market Growth**  
Jun-Ho Park, POSCO

POSCO has developed strip casting and wide rolling technology to reduce a cost and improved strip quality from 2007. Based on these efforts, Mg strip was successfully adapted to automobile items commercially, starting from partition panels of sedan. POSCO is widening its application items from inner to outer panels of automobile. Many alloys were developed for high conductivity, high room temperature formability and high strength through strip casting. As one of developed results, new alloy can remarkably reduce forming temperature without decreasing yield strength and has a target to achieve the formability of Al 5000 series. Up to date, POSCO has made an effort to enhance room temperature formability. In order to widen Mg strip application to automobile in the future, part cost should be lowered more. Alloy development efforts should be added to increase the corrosion resistance for external part, even though the technology of refining impurity element in melt and surface pretreatment was developed.

**Magnesium Alloy Development And Manufacturing Innovation For Lightweight Applications**  
Alan A. Luo, Ohio State University

Materials, manufacturing and design are critical pillars in engineering applications. As the lightest structural metal, magnesium has emerged as a promising material for lightweight applications in automotive, aerospace, electronics and consumer products. This paper presents examples of magnesium alloy development using phase equilibria calculations and experimental validation. The paper will also summarize the latest innovations in manufacturing process (casting, forming and joining) for magnesium applications. Process simulation and multi-scale microstructure modeling techniques are used to develop and optimize these manufacturing processes. Engineering design is a system optimization and iteration process that combines material properties and manufacturing processes to meet product requirements at the lowest mass and/or cost. Future trends in multi-material applications including magnesium and the integrated computational materials engineering (ICME) are also discussed.
For many applications in the automotive and railway industries the crashworthiness of a structure is an important property which must be addressed by design engineers. Crashworthiness is not a physical property itself, but correlates with the material’s ductility and structural design. Magnesium is known to be a material with lower failure strain than other metallic structural materials. Therefore the use of magnesium in crash-related areas is more challenging compared to steel and aluminum.

The DLR-Institute of Vehicle Concepts has developed several solutions for magnesium castings, extrusions and sheet-metal parts capable of bearing crash loads. The paper will show the potentials and properties of different technological approaches. In collaboration with researchers from the University of Windsor and the University of Waterloo, novel technologies for energy absorption, involving cutting deformation, with magnesium were investigated, tested and compared to traditional axial crushing deformation modes. Results of the joint research will be presented.

To the best of our knowledge, this is the largest report of patients in Orthopedic Surgery treated with self-degradable screws made of a specific magnesium alloy (MAGNEZIX). Between 2008 and 2013 the compression screw 3.2 was developed in laboratories in Hanover and Clausthal-Zellerfeld. After animal testing and a clinical study the MAGNEZIX CS 3.2 got the CE approval in 2013. Since then the company Syntellix AG sold more than 2000 screws and - in Germany alone - more than 250 patients have been operated on. We report the history of development and the clinical experiences with the only screw for clinical use in orthopedic surgery worldwide; 26 patients were operated in the clinical study for hallux valgus operation; more than 200 are included in a post-marketing clinical trial. First clinical results will be presented.

The use of any material is governed by the forms in which it can be produced. Magnesium alloys have generally been produced through casting or wrought process
technologies at elevated temperature. These techniques have enabled many complex near-net shape components as well as sheet and bar products for structural applications.

Interest in magnesium alloys as temporary medical implant materials continues to grow. However, medical devices require fine dimensions and precision not possible with traditional magnesium processing technologies. Toward this end, a process to realize cold-drawn magnesium alloy wire has been developed. Cold drawing enables extremely fine diameters and excellent mechanical properties. In WE43, for example, tensile strengths as high as 695 MPa and diameters as small as 25 microns have been achieved.

This paper will discuss potential medical and lightweight magnesium alloy applications enabled by cold drawing.

**No-Combustible Magnesium Alloy Adapted For Building Material**

Hiroaki Tanaka, *Gonda Metal Industry, Co. Ltd.*

At Tohoku earthquake in Japan 2011, suspended ceilings were tumbled down and great deal damage was done. The light weight equipment has been demanded in construction industry for countermeasure against earthquake and for energy conservation. Using constructive material in authorization of Ministry of Land, Infrastructure, Transport and Tourism of Japan for non-combustible is obligatory. And acquiring non-combustible material is strict. We have succeeded in producing non-combustible magnesium wrought sheet including 2%calcium by our Twin Roll Casting System (GTRC), and we and ASAHISANNKO, one supplier of building materials, acquired its authorization jointly in November ‘13. This material was determined to use for ceiling reformation of gymnasium of primary school in Tokyo. It might be the first in the world as building material. This technology will highly contribute to our society and will make wrought products of Magnesium prevail in the construction industry.

**Scan Magnesium’s And Nevada Clean Magnesium’s Advances In Utilization Of The Silicothermic Process**

Edward Lee, *Nevada Clean Magnesium, Inc. And Scan Magnesium AS*

Both Nevada Clean Magnesium and Scan Mag are intent on constructing and operating primary magnesium smelters using silicothermic reduction to produce 99.8 magnesium. The proposed approach being taken to produce the metal is described together with improvements which decrease the cost of production and improve the environment.
Molten magnesium and its alloys need to be protected due to their high affinity to oxygen. Even if an oxide film forms on molten Mg, it will not protect a melt against oxidation due to a Pilling-Bedworth ratio smaller than 1 leading to a porous film. SF6 effectively protects molten Mg and is state of the art. Other fluorinated hydrocarbons like HFC134a, Novec612, AMCover are already used by some foundries and recyclers. But they are already under discussion due to their high GWP and critical by-products. SO2 and HFC134a are named by EU as best available solutions, but both also have their limits. SF6 will be banned in EU from 2018 and there is likelihood that this will also hit other fluorinated hydrocarbons. Due to this, it is necessary to reconsider existing methods and perhaps to find new innovative ways to protect molten Mg e.g. like the use of Ca/CaO.