Supply Trend and LCA of Resources for PV

Kohmei HALADA
principal of Center for Strategic Natural Resource
NIMS, Japan
Eco-innovation requires new demand of rare & special materials.
As the climate change is getting important, therefore, we need to take care of other risks.

Catastrophe comes from neighboring risks.
component

counter attack of pico-gram

man-made hazardous substance

人工有害物質

flood of man-made materials

人工物の氾濫

curtailment of regeneratibility

自然の再生基盤縮小

surplus usage of material

過剰な物質使用・転化

mass

overflow of Giga ton

Latent Pollution

Latent Resource requirement
restriction of resource

• A) restriction from the amount and distribution of resource: Usable amount of resource is limited by the technology of the age, and the concentrated sites are localized. --- Au, Ag, Cu, PGM, Zn, In, etc.

• B) restriction from energy: Metals which have great affinity with oxygen require considerable amount of energy to be reduced from ore. --- Si, Ti, Al, etc.

• C) restriction from environment: Excavation and extraction exhausts a considerable amount of waste soil, waste water or waste material. --- REE
Resource risk which is raised by these constrains and the rapid growth of demand is widely discussed from different viewpoints.

• 1) Viewpoint of global environment: the increase of environmental burden in mining resources, accelerated by the expansion of the use of rare metals which have great TMR (Total Material Requirement), and also multiplicated by degradation of ore which can be mined.

• 2) Viewpoint of human’s activity: closing to the exhaustion of resource, and affected instability of supply and costs.

• 3) Viewpoint of national economy: Many countries obtain their fundamental resources by international trade. The break of supply collapses the countries economy.
• PV technology requires three different types of materials, one type is material for energy conversion. Si, Ge, Ga, As, Cu, In, Se, Cd, Te, TiO2, I, Ru are used. Fortunately Si, Ti, I are abundant resources and others are obtained as byproducts from Cu or Zn. (Ru is also a byproduct of Pt.)

• The second type of materials is the material which has function of transparent and transporting of photon or electron. Transparent layer, reflection layer, electrode, conductive materials are included in this category. Sn, Zn, Mo, Pt, Cu are used. In this category, efficient use is required in the design because of they are frequently classified in the group of critical metals.

• The third group is not special material for PV but necessary to make infrastructure of PV system. Weather resistance flames and stands and electric wire are in this group. Nickel and Chromium as the elements of stainless steel are required. Zn is also used as zinc coated steel plate. and Cu is used as cable.
Material involves a large amount of materials behind.

Ecological rucksacks  
TMR: Total Materials Requirements
TMR of metals plotted on the periodic table
Share of one country: more than 75% : R.E., Th, Nb, W, Rh, Pt
Share of top three country more than 80% : Pd, Te, V, Ta, Be, Zr, Tl, Bi
Material Flow of Si for semiconductor

2006
Material Flow of Ge in Japan
Germanium

- The available resources of germanium are associated with certain zinc and lead-zinc-copper sulfide ores.
- Significant amounts of germanium are contained in ash and flue dust generated in the combustion of certain coals for power generation.
- Reserves exclude germanium contained in coal ash.
Material Flow of Ga in Japan
Gallium (2009)

- World primary production was estimated to be 78 tons.
- China, Germany, Kazakhstan, and Ukraine were the leading producers.
- Smaller output were Hungary, Japan, Russia, and Slovakia.
- Refined gallium production was about 118 tons, including scrap refining.
- China, Japan, and the United States were the principal producers of refined gallium.
- Gallium was recycled from new scrap in Germany, Japan, the United Kingdom, and the United States.
- World primary gallium production capacity in 2009 was 184 tons; refinery capacity, 167 tons; and recycling capacity, 78 tons.
- Assuming that the average content of gallium in bauxite is 50ppm, world resources of gallium in bauxite are estimated to exceed 1 million tons, and a considerable quantity could be present in world zinc reserves.
material flow of In in Japan
Indium

In Production 600ton (2009)
material flow of Se in Japan
Selenium

Se Production 1,390

Se Reserve 82,000
Tellurium

Te Production 128ton (2006)

Te Reserve 21,000ton (2006)
Cadmium

Cd refinery

Cd reserve
material flow of Cd in Japan
Arsenic

As2O3 Production 53,500 ton (2009)
Iodin

I Production 27,000ton (2009)

I Reserve 15Mton (2009)
Tin

Sn Mine 307,000ton (2009)

Sn Reserve 5,600,000
Four types of the two step line model of metal consumption v.s. GDP per capita

Fe-type: weakly de-coupled  
Al, Ni, Mo, Ag, Sb

Zn-type: de-coupled  
Cu, Sn, Pb, W, Cr, Mn, Au

Si-type: still coupling  
Pt, Co

R.E.-type: further coupling  
Li, In, Ga

Fe

y = 0.0064x + 440  
R² = 0.4506

Zn

y = -3.13E-05x + 6.74E+00

y = 0.056x  
R² = 0.9501

Si

y = 3.91E-05x

R.E.

y = 0.0057x

y = 2.19E-03x

Fe


Zn

1960

Si

y = 3.91E-05x

R.E.

y = 0.0057x

y = 2.19E-03x
Several times amount of resources will be required by 2050.

It will be close to the amount of reserve by 2050: Fe, Mo, W, Co, Pt, Pd

It will require several times amount of reserve by 2050: Ni, Mn, Li, In, Ga

It will run over the amount of reserve base by 2050: Cu, Pb, Zn, Au, Ag, Sn
While materials play an essential role in the development of human society, their negative aspects of environmental burden through the massive production, consumption, and disposal have been pointed out. The demand for materials is now expanding further in order to satisfy growing human needs. It may cause a rapid increase in the resource risk. We, who aim to utilize materials to construct a sustainable society, reconfirm the importance of the following three principles.

Three principles in the area of resource use
- Resource Conservation
- Environmental Protection
- Regional and Generational Equity

Based on these principles, we ask you, consumers of materials, to observe the following four practices. We also pledge ourselves to advance technologies which realize these four practices in material research.

Four practices in the area of resource use
- Use minimum quantity
- Use completely
- Circulate as many times as possible
- Use abundant resources

International Symposium of Sustainable Energy and Material was held at 2007 at Ishigaki Island, Japan to discuss the contribution of materials science and engineering to sustainable use of energy and resource.