Gallium

By E. Chin [1]

Domestic production of gallium in 1972 increased sharply over production in the previous year. Most of the gallium consumption was for the production of gallium intermetallic compounds used in light-emitting diodes for electronic visual display panels. Sales of gallium-arsenide-phosphide for optoelectronic devices were estimated at $14.5 million in 1972, up from $4 million in 1971.

DOMESTIC PRODUCTION

Production of gallium metal in 1972 by two companies was more than double that in 1971. The sharp rise in production was attributed to increased demand for gallium by the electronics industry.

Gallium metal was produced as a by-product of alumina production by the Aluminum Company of America (Alcoa) at its Bauxite, Ark., plant. Gallium metal, oxide, and trichloride were produced by Eagle-Picher Industries, Inc., at its Quapaw, Okla., plant. Production data are company confidential. In addition, gallium metal and compounds produced primarily from imported material were supplied by Alusuisse Metals, Inc., Atomergic Chemetals Co., Cominco American, Inc., European Electronics, Inc., B. Freudenberg, Inc., Indium Corporation of America, Kawecki Berylco Industries, Inc., and Ventron Corp.

Alcoa announced a breakthrough in production technology which reportedly will enable the company to triple its gallium production capacity at the Bauxite, Ark., plant. Additional gallium production may be possible at Alcoa's refineries at Mobile, Ala., and Point Comfort, Tex.

Canyon Land 21st Century Corp. (Canyon Land), Blanding, Utah, is expected to begin production of gallium in late 1973. Canyon Land will use as its raw material source, gallium contained in phosphate residues, which will be provided by the Monsanto Company.

CONSUMPTION

The largest use of gallium was in electronic applications, principally in the form of gallium arsenide and gallium phosphide, which are used in solid state lamps (light-emitting diodes, LEDS). Due to the pronounced trend of the electronics industry towards microminiaturization, LEDS were increasingly used in visual display systems in calculators, digital clocks, medical instrumentation, multiple warning lights, and instrumentation for aircraft and automotive dash panels. A novel use for LEDS was in the production of electronic watches in which the time display system is based on a gallium lamp matrix. The manganese-doped magnesium-gallium spinel ($MgGa_2O_4$:Mn) is a green phosphor used in ultraviolet excitation and is used in fluorescent lamps in Xerox copying machines. Gallium compounds were also used in semiconductor applications for microswitching devices and in microwave and laser applications. The intermetallic compound vanadium-gallium, V_3Ga, is a superconductor with a high transition temperature and a high critical field.

In research and development there was growing interest in the gadolinium-gallium garnet, $Gd_3Ga_5O_{12}$, as a substrate material for magnetic bubble domain devices. Gallium trichloride was investigated as a Friedel Crafts reagent in organic synthesis.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Stocks, receipts, and consumption of gallium as reported by consumers

(Grams)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
1971:				
97.0%–99.9%	15,405	13,550	11,959	16,996
99.99%	2,444	1,674	1,608	2,510
99.999%	3,175	28,100	30,335	940
99.9999%–99.99999%	73,207	2,339,005	2,244,980	167,232
Total	94,231	2,382,329	2,288,882	187,678
1972: p				
97.0%–99.9%	16,996	10,591	12,692	14,895
99.99%	2,510	51,000	51,513	1,997
99.999%	940	10,249	1,664	9,525
99.9999%–99.99999%	167,232	5,992,586	5,010,336	1,149,482
Total	187,678	6,064,426	5,076,205	1,175,899

p Preliminary.

Table 2.—Consumption of gallium, by end use

(Grams)

End use	1971	1972 p
Alloys [1]	10,124	31,116
Electronics [2]	2,037,696	4,965,717
Research and development	136,070	78,670
Unspecified uses	104,992	702
Total	2,288,882	5,076,205

p Preliminary.
[1] Dental, brazing, and specialty alloys.
[2] Primarily for light-emitting diodes; includes semiconductors and color television phosphors.

Approximately 98% of the gallium consumed in 1972 was for electronic applications. Major consuming firms included Bell and Howell Co., Bell Telephone Laboratories, Inc., Fairchild Research and Development Laboratories, Hewlett-Packard Laboratories, Laser/Diode Laboratories, Inc., Litronix Inc., Monsanto Company, Motorola, Inc., Opcoa, Inc., RCA Corp., Texas Instruments, Inc., Texas Materials Laboratories, Inc., and Western Electric Co.

Strata Physics, Inc. (Strata), a user of gallium compounds for the production of optoelectronic materials, doubled the size of its plant at Santa Clara, Calif. Orders for Strata's optoelectronic materials in 1972 were reportedly over $2.4 million.

STOCKS

Consumer stocks of gallium metal, low- and high-purity grades, totaled 1,175,899 grams as of December 31, 1972. Stocks a year earlier were 187,678 grams. Shipments of gallium metal as reported by producers, dealers, and traders in 1971 and 1972 were, respectively, 853,069 grams and 3,157,634 grams. Gallium metal stocks, in grams, as held by producers and suppliers were as follows:

Year	January 1	December 31
1971	211,362	402,875
1972	402,875	1,005,945

PRICES

The average price per gram of gallium metal as quoted by domestic producers in 1972 were as follows:

Quantity	Purity designation		
	99.99%	99.999%	99.9999% 99.99999%
50 to 999 grams	$0.90	$1.05	$1.20
1,000 to 4,999 grams	.60	.65	.80
5,000 to 24,999 grams	.55	.60	.75

For orders over 500 kilograms of gallium between 6–9's and 7–9's purity, the selling price of metal was reportedly between $0.60 and $0.65 per gram. The price of a single LED unit as quoted by Monsanto Company was as follows:

Color	Composition	Quantity			
		1–9	10–99	100–999	Over 1,000
Amber	Gallium-arsenide-phosphide	$1.50	$1.50	$1.15	$0.99
Green	Gallium phosphide	13.50	11.00	9.25	8.00
Red	Gallium-arsenide-phosphide	0.62–1.65	0.62–1.65	0.50–1.30	039–1.10

FOREIGN TRADE

Exports of gallium are not reported separately and are included in base metals and alloys, not elsewhere classified, wrought or unwrought, waste and scrap.

Total U.S. imports of gallium in 1972 were 13,372 pounds valued at $2,715,179, compared with 5,889 pounds valued at $1,182,118 in 1971. The unit value of gallium imports ranged from $290 per kilogram for material from Italy to $530 per kilogram for gallium from the United Kingdom. The average unit value of all gallium imports in 1972 was $415 per kilogram.

Table 3.—U.S. imports for consumption of gallium (unwrought, waste and scrap), by country

Country	1971		1972	
	Pounds	Value	Pounds	Value
Canada	587	$129,844	3,077	$696,186
Germany, West	403	70,712	274	45,479
Hong Kong	--	--	9	1,426
Hungary	--	--	4	680
Italy	--	--	344	45,369
Japan	1	364	34	5,985
Netherlands	133	32,693	322	74,015
Switzerland	4,319	854,662	9,099	1,795,792
United Kingdom	[1] 446	[1] 93,843	209	50,247
Total	[1] 5,889	[1] 1,182,118	13,372	2,715,179

[1] Adjusted by the Bureau of Mines.

WORLD REVIEW

Canada.—Chemalloy Minerals Limited (Chemalloy) of Toronto agreed to ship samples of the tailings containing gallium from its tantalum mining operation at Bernic Lake, Manitoba, to Cominco Ltd., Kawecki Berylco Industries, Inc., and Eagle-Picher Industries, Inc. to investigate gallium extraction from the tailings. The mine at Bernic Lake, about 100 miles north of Winnipeg, is operated through Chemalloy's wholly owned subsidiary, Tantalum Mining Corp. of Canada Limited (Tanco). In addition to tantalum ore, Tanco mines pollucite, a cesium raw material source.

Tanco obtained research assistance from the University of Manitoba and financial aid from the Manitoba Research Council to investigate gallium recovery from the Bernic Lake operation. The study includes the determination of the point of maximum concentration of gallium in the process of recovering tantalum and the development of a gallium extraction process.

Cominco Ltd. recovered gallium as a byproduct from its zinc plant at Trail, British Columbia.

Japan.—Gallium production in Japan for 1968–72, estimated by the Japan Society of Newer Metals, was as follows:

Year	Kilograms
1968	100
1969	150
1970	175
1971	210
1972	500

Gallium production in 1972 was by the Dowa Mining Co., Ltd. and Nippon Light Metal Co., Ltd. Gallium intermetallic compounds were manufactured by Mitsubishi Metal Corp., Nippon Light Metal Co., Ltd., Sumitomo Electric Co., Ltd., and Sumitomo Metal Mining Co., Ltd.

Sumika Alusuisse Gallium Ltd. (Sumika), a joint venture between Swiss Aluminium Ltd. (Alusuisse) and Sumitomo Chemical Co., was formed in Japan to produce gallium metal as a byproduct of alumina production. Sumika was to establish a $2.5 million plant at Nijhama with a gallium production capacity of 2,000 kilograms per year; initial startup was scheduled for late 1973. Alusuisse was to provide the technical know-how for the installation and operation of the plant.

Dowa Mining Co., Ltd. (Dowa) increased its gallium production capacity from 5 kilograms per month to 100 kilograms per month at its Kosaka (Akita Prefecture) plant. The gallium raw material source for the Kosaka plant was from residues from the Iijima zinc smelter which is operated by Dowa's subsidiary, Akita Zinc Co. (Akita Zinc). Akita Zinc reportedly produced sufficient residue to allow recovery of 200 kilograms of gallium a month.

Netherlands.—N. V. Billiton Maatschappij (Billiton), in partnership with Kawecki Berylco Industries, Inc. (KBI), formed N. V. Kawecki-Billiton Metaalindustrie (Kawecki-Billiton), which replaced the Special Metals Division of Billiton. KBI became the exclusive sales agent in the United States and Canada for Kawecki-Billiton's ultra-high-purity metals which, in addition to gallium, include antimony, arsenic, bismuth, cadmium, copper, gold, indium, lead, tellurium, and tin.

World producers of gallium by company, location, and raw materials source are as follows:

Country	Company	Location	Source
Canada	Cominco Ltd	Trail, British Columbia	Zinc ore.
China, People's Republic of	NA	NA	NA.
Czechoslovakia	NA	NA	NA.
France	Alusuisse France S.A	Marseilles	Bauxite.
Germany, West	Martinswerk G.m.b.H. fur Chemische und Metallurgische Produktion.	Bergheim/Erft.	Do.
Hungary	NA	NA	NA.
Italy	Società Alluminio Veneta Azioni	Porto Marghera	Bauxite.
Japan	Dowa Mining Co., Ltd	Kosaka	Zinc ore.
	Nippon Light Metal Co., Ltd	Shimizu	Bauxite.
	Sumika Alusuisse Gallium Ltd	Nijhama	Do.
	Toho Zinc Company	Fujioka	Zinc ore.
Norway	Vigeland Metal Refinery A/S	Vigeland	High-purity aluminum.
Switzerland	Alusuisse Research Laboratories	Neuhausen am Rheinfall.	Crude gallium metal.
U.S.S.R.	NA	NA	NA.
United States	Aluminum Company of America	Bauxite, Ark.	Bauxite.
	Eagle-Picher Industries, Inc	Quapaw, Okla.	Zinc ore.

NA Not available.

TECHNOLOGY

International Business Machines Corp. announced the development of a new type of solar cell that is more efficient than existing cells in converting sunlight to electricity.[2] The new solar cell was capable of converting 18% or more of the energy of the sunlight into electricity, older cells were typically 11% to 13% efficient. The cell is composed of a gallium arsenide layer and a layer of gallium-aluminum-arsenide doped with zinc atoms. The new cell reportedly could operate at higher temperatures than other cells and was more resistant to electron and proton radiation.

Crystals of gadolinium-gallium-garnet were produced at the Bell Laboratories using a computer-controlled crystal-growing method.[3] In this method, a digital scale records the weight of the molten material from which the rare-earth garnet is drawn. The computer uses the change in weight of the molten metal to calculate the rate of change of the crystal weight, which provides an indication of the diameter of the crystal as it is formed. The gadolinium-gallium-garnet is used as a substitute material for magnetic bubbles, a new development by the Bell Laboratories, for information storage in electronic switching systems and in computers.

GEC-Marconi Electronics of Chelmsford, England, developed a compact, thin radar

[2] Wall Street Journal. New-Type Solar Cell Developed by IBM. V. 179, No. 93, May 11, 1972, p. 15.

[3] American Metal Market. Crystals of Gadolinium Produced at Bell Labs. V. 79, No. 176, Sept. 26, 1972, p. 11.

display screen based on a matrix of light-emitting gallium-arsenide-phosphide diodes.[4] The new screen is reported to be more functionally reliable and, because it uses less than 20% of the power of conventional cathode ray tubes, it runs at a much lower temperature.

The RCA Laboratories in Princeton, N.J., produced the first instance of superconductivity of an alloy containing only two elements at a temperature higher than 20° K.[5] The new material, niobium-gallium, was superconductive at 20.3°K, which could reduce cooling costs for the superconductive phenomenon by 75% and could hasten practical applications in electric motors, generators, and transmission lines.

A patent was issued on the recovery of gallium values from circulating aluminate solution used in the Bayer process for producing alumina.[6]

The proceedings of a conference held at Pebble Beach, Calif., on optoelectronics were published by the Materials Research Corporation.[7] Papers on the technology of growing single crystals of gallium arsenide and gallium phosphide and the evaluation of optoelectronic materials were included in the proceedings.

---

[4] Chemical and Engineering News. Concentrates—Technology. V. 50, No. 37, Sept. 11, 1972, p. 16.

[5] Chemical and Engineering News. Concentrates—Technology. V. 50, No. 35, Aug. 28, 1972, p. 13.

[6] Mihake, S. (assigned to Chuo Tatemono Co., Ltd.). Electrowinning. U.S. Pat. 3,677,918, July 18, 1972.

[7] Materials Research Corporation. Optoelectronics, The Technology of Optoelectronic Materials. Orangeburg, New York, 1972.