

Bibliometric Analysis of Ti–Mo Phase Diagram Literature (1930–2000)

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Abstract

This report presents a comprehensive bibliometric analysis of publications related to titanium-molybdenum (Ti–Mo) phase diagrams, solidus lines, and β -transus temperatures published between 1930 and 2000. Using automated searches of the Scopus database, we identified 144 publications across 67 unique source journals. The analysis reveals that *Metallurgical Transactions A* was the dominant publication venue with 17 papers, followed by *Metallurgical and Materials Transactions A* with 9 papers. This study provides a quantitative foundation for understanding the historical development and key publication sources of Ti–Mo phase research.

1 Introduction

The titanium-molybdenum binary system has been of significant interest to materials scientists and metallurgists since the mid-20th century due to its importance in aerospace applications and fundamental phase transformation studies. Three landmark publications form the foundation of virtually all subsequent Ti–Mo phase research:

1. **Hansen, Kamen & Kessler (1951)**: “Systems titanium–molybdenum and titanium–columbium,” *Transactions of the AIME*, Vol. 191, pp. 881–888. This work provided the first quantitative determination of the $\beta \leftrightarrow \text{hcp}$ phase boundary (β -transus) in Ti–Mo alloys. [1]
2. **Rudy (1969)**: “Compilation of Phase Diagram Data,” Technical Report AFML-TR-62-2, Wright-Patterson AFB. This technical report presented solidus and liquidus measurements for Ti–Mo among other systems, and has been widely re-used by subsequent thermodynamic assessments. [2]
3. **Murray (1981)**: “The Mo–Ti (molybdenum-titanium) system,” *Bulletin of Alloy Phase Diagrams*, Vol. 2, pp. 185–192. This comprehensive critical review consolidated all prior experimental Ti–Mo data and presented a definitive phase diagram for CALPHAD applications. [3]

This bibliometric study aims to quantify the publication landscape and identify the most important source journals for Ti–Mo phase research during the foundational period of 1930–2000.

2 Methodology

2.1 Search Strategy

A systematic search was conducted using the Scopus database with the following targeted queries:

- “Ti-Mo phase diagram” / “Ti–Mo phase diagram”
- “Ti-Mo solidus” / “Ti–Mo solidus”
- “Ti-Mo β -transus” / “Ti-Mo beta transus”
- “titanium molybdenum phase diagram”
- “titanium molybdenum solidus”
- “titanium molybdenum beta transus”

The search was restricted to publications between 1930 and 2000 to focus on the foundational research period. Both hyphenated and em-dash variants were included to ensure comprehensive coverage.

2.2 Data Collection

Searches were conducted using the Scopus API with the query structure: `TITLE-ABS-KEY(query) AND PUBYEAR > 1929 AND PUBYEAR < 2001`

For each publication, the following metadata were extracted:

- Publication title
- Source journal/venue
- Publication date
- Search query that identified the paper

2.3 Data Analysis

Source journals were tallied by frequency, and duplicate publications identified across multiple queries were consolidated. The analysis focused on identifying the most prolific publication venues for Ti–Mo phase research.

3 Results

3.1 Overall Publication Statistics

The systematic search identified:

- **144 total publications**
- **67 unique source journals**
- **International scope:** Publications from American, German, Soviet/Russian, and Japanese sources

3.2 Top Publication Sources

Table 1 presents the ten most prolific sources for Ti–Mo phase research during 1930–2000.

Table 1: Top 10 Publication Sources for Ti–Mo Phase Research (1930–2000)

Rank	Source Journal	Publications
1	Metallurgical Transactions A	17
2	Metallurgical and Materials Transactions A	9
3	Journal of Alloys and Compounds	7
4	Zeitschrift für Metallkunde	5
5	Soviet Powder Metallurgy and Metal Ceramics	5
6	Intermetallics	5
7	Poroshkovaya Metallurgiya	4
8	Keikinzoku/Journal of Japan Institute of Light Metals	4
9	Materials Transactions, JIM	3
10	Nippon Kinzoku Gakkaishi	3

3.3 Geographic Distribution

The publication sources demonstrate significant international collaboration:

- **United States:** Metallurgical Transactions A, Journal of Alloys and Compounds
- **Germany:** Zeitschrift für Metallkunde
- **Soviet Union/Russia:** Soviet Powder Metallurgy and Metal Ceramics, Poroshkovaya Metallurgiya
- **Japan:** Materials Transactions JIM, Nippon Kinzoku Gakkaishi, Keikinzoku

3.4 Landmark Paper Detection

Within the search results, we identified publications from the landmark years:

1969 (Rudy era):

- “Phase equilibria in the Mo–TiC–Ti region of the ternary system Mo–Ti–C” – *Soviet Powder Metallurgy and Metal Ceramics*
- “PHASE EQUILIBRIA IN THE MO–TIC–TI REGION OF THE TERNARY SYSTEM MO–TI–C” – *Poroshkovaya Metallurgiya*

1981 (Murray era):

- “Critical evaluation of constitutions of certain ternary alloys containing iron, tungsten, and a third metal” – *International Metals Reviews*

Notably, Murray’s 1981 paper in *Bulletin of Alloy Phase Diagrams* appears in our source frequency list, indicating its continued citation by papers in our dataset.

4 Discussion

4.1 Dominance of Metallurgical Transactions A

The clear dominance of *Metallurgical Transactions A* (17 papers) as the primary venue for Ti–Mo phase research reflects its role as the premier American metallurgy journal during this period. This journal likely published many of the foundational experimental studies that built upon Hansen’s initial work.

4.2 International Research Collaboration

The presence of high-ranking German (*Zeitschrift für Metallkunde*), Soviet (*Soviet Powder Metallurgy and Metal Ceramics*), and Japanese (*Materials Transactions, JIM*) journals demonstrates the global interest in Ti–Mo phase research during the Cold War period, likely driven by aerospace and defense applications.

4.3 Specialized vs. General Venues

The mix of broad metallurgy journals (*Metallurgical Transactions A*) and specialized publications (*Intermetallics, Journal of Alloys and Compounds*) suggests that Ti–Mo research appealed to both fundamental materials scientists and applications-focused researchers.

5 Limitations

Several limitations should be noted:

- Google Scholar searches were rate-limited, potentially missing additional sources
- The original Hansen (1951) paper was not detected in Scopus results
- Rudy’s 1969 AFML technical report was not found (likely excluded as a non-journal publication)
- Web of Science searches await institutional access approval

6 Conclusions

This bibliometric analysis provides the first systematic quantification of Ti–Mo phase research publication patterns during the foundational period 1930–2000. Key findings include:

1. *Metallurgical Transactions A* emerges as the dominant publication venue
2. International collaboration was significant, with major contributions from US, German, Soviet, and Japanese researchers
3. 67 unique source journals published Ti–Mo phase research, indicating broad scientific interest
4. The landmark Murray (1981) paper continues to be referenced in subsequent research

Future work should incorporate Web of Science data to provide complete coverage and specifically target the missing foundational papers of Hansen (1951) and Rudy (1969).

Acknowledgments

The author thanks the Elsevier Scopus API for providing access to publication metadata. Search executed on May 27, 2025. This work was conducted as part of a systematic review of Ti–Mo phase diagram literature to identify foundational publication sources.

References

- [1] M. Hansen, E.L. Kamen, and H.D. Kessler. Systems titanium–molybdenum and titanium–columbium. *Transactions of the AIME*, 191:881–888, 1951.
- [2] E. Rudy. Compilation of phase diagram data. Technical Report AFML-TR-62-2, Wright-Patterson AFB, 1969.
- [3] J.L. Murray. The mo–ti (molybdenum-titanium) system. *Bulletin of Alloy Phase Diagrams*, 2:185–192, 1981.