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3D Ga-Li-Cu-Mn-Si – Synergy of a series of phases with Mn-centered Cu-Mn-Si tetrahedral clusters, Li-centered Ga-Li-Si tetrahedral clusters and Ga-centered Ga-Li-Si tetrahedral clusters – crystal structure and properties

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Abstract: Three new ternary phases, Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (I), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (II) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (III), were synthesized by arc melting of the elements and subsequent annealing at 800 °C. The crystal structures of I, II and III were determined by single-crystal X-ray diffraction analysis. I crystallizes in the orthorhombic space group Pnma (No. 62) with a = 6.9(1) Å, b = 4.2(1) Å, c = 7.1(1) Å, V = 206(1) Å^3, Z = 4, II crystallizes in the orthorhombic space group Pnma (No. 62) with a = 6.9(1) Å, b = 4.2(1) Å, c = 7.1(1) Å, V = 206(1) Å^3, Z = 4, and III crystallizes in the orthorhombic space group Pnma (No. 62) with a = 6.9(1) Å, b = 4.2(1) Å, c = 7.1(1) Å, V = 206(1) Å^3, Z = 4. The structures of I, II and III are isotypic and consist of Cu-centered Cu-Mn-Si tetrahedral clusters, Li-centered Ga-Li-Si tetrahedral clusters and Ga-centered Ga-Li-Si tetrahedral clusters. The Cu-centered Cu-Mn-Si tetrahedral clusters are connected to form 1D infinite chains along the [010] direction. The Li-centered Ga-Li-Si tetrahedral clusters are connected to form 1D infinite chains along the [010] direction. The Ga-centered Ga-Li-Si tetrahedral clusters are connected to form 1D infinite chains along the [010] direction. The 1D infinite chains are connected to form 3D infinite framework structures. The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (IV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (V) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (VI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (VII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (VIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (IX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (X), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XIV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XVI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XVII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XVIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XIX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXIV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXVI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXVII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXVIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXIX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXIV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXVI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXVII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXVIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXIX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXIV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXVI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXVII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXVIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXIX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXIV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXVI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXVII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXVIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXIX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXIV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXVI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXVII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXVIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXIX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXIV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXVI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXVII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXVIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXIX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXIV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXVI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXVII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXVIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXIX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXIV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXVI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXVII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXVIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXIX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXIV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXVI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXVII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXVIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXIX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXIV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXVI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXVII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXVIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXIX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXIV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXVI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXVII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXVIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXIX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXIV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXVI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXVII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXVIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXIX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXIV). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXVI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXVII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXVIII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXIX) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXI), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXIII). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXIV), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXV) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXVI). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXVII), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXVIII) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXIX). The 3D infinite framework structures of I, II and III are isotypic to the 3D infinite framework structures of Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXX), Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXXI) and Ga$_{2.0(1)}$Li$_{1.0(1)}$Cu$_{1.0(1)}$Mn$_{1.0(1)}$Si$_{1.0(1)}$ (XXXXXXXXXXXXXXXXII). The 3D infinite framework structures of I, II and III are isotypic to the 3D inf